ESTABLISHING A TRAUMA REGISTRY IN THE EMIRATE OF ABU DHABI

By

Saleh Fares Al-Ali

A dissertation submitted to Johns Hopkins University in conformity with the

requirements for of the degree Doctor of Public Health

Baltimore, Maryland

April 2021

ABSTRACT

***Background*:** Trauma has been identified as one of the top 10 public health priorities in Abu Dhabi because of its medical and economic impact. Trauma is the second leading cause of death in the United Arab Emirates (UAE), which results in both physical and psychological impacts on patients, their families and society at large. To reduce the mortality, morbidity and improve trauma care, a trauma-interested group in Abu Dhabi took the initiative to establish a trauma registry in the Emirate of Abu Dhabi.

***Objectives*:** This paper evaluates the efforts in developing the registry, identifies opportunities for improvement, and provides the first summary of data collected to date. Specifically, we: (1) evaluated the quality of the registry and identified areas for improvement; (2) used the registry data to examine the epidemiology of trauma and outcomes in Abu Dhabi; and (3) studied the epidemiology of falls in the registry.

***Methods*:** Data from seven facilities in Abu Dhabi entered into the registry between 2014 and 2017 were extracted from the registry. Data quality was assessed using seven domains including: Completeness; Accuracy; Precision; Correctness; Consistency; Timeliness; and Coverage. Data quality was assessed using a set of 14 pre-selected variables. A retrospective observational study based on the data was conducted to evaluate the epidemiology of trauma overall, as well as the epidemiology of falls in the Emirate of Abu Dhabi. Statistical analysis was performed using STATA/IC version 16. Regression was performed to assess the impact of age, gender, mechanism of trauma, and ISS score on mortality and length of hospital stay.

***Results*:** Starting from a total of 20,562 cases, after excluding 2,735 cases, a random sample of 5% was selected from the remaining 17,827 cases and the data quality was assessed on a sample of 891 cases. Completeness, Accuracy, Correctness, and Consistency showed very high quality overall. Data Timeliness was considered reasonably acceptable since overall, around 70% of data were entered within 60 days and 73% within 90 days of the injury. For Coverage, currently the data registry is comprised of data from the seven facilities in Abu Dhabi; 100% coverage will eventually be achieved once the registry expands to other health institutes in Abu Dhabi.

As for the epidemiology of trauma in the Emirate of Abu Dhabi, an analysis of the 17,827 cases was conducted which showed that the majority of patients were male, aged 21 to 50 years old. The two major mechanisms of injuries (over 70%) were road traffic injuries (39%) and falls (34%). Out of the total trauma hospital admissions, over 60% of the cases were ISS category < 9; and only 5% of the cases were admitted with ISS category 25 and above.

Overall, the mean length of hospital stay was 6.49 days. The overall mortality in our sample was 1.41%, with the highest case fatality caused in road traffic injuries (57%), followed by falls (21%). Falls mainly occurred at *home* (55%) and in the *workplace* (21%). For the overall data and falls specifically, the regression analysis suggests a statistically significant increase in the length of a patient's hospital stay with increasing age and increasing ISS score. There was no difference in the length of hospital stay or mortality rates by gender. Mortality was significantly higher for falls from > 6 meters compared to falls < 1 meter and 1–6 meters.

***Conclusion*:** This dissertation presents the first analysis of the Abu Dhabi Trauma Registry data since its establishment in 2014. It provides insights on data quality, the epidemiology of trauma, and the determinants of falls. Such findings will help plan and implement future policies related to trauma prevention and management in the Emirate of Abu Dhabi specifically and the region as a whole.

<u>Thesis Readers:</u>

Prof. Adnan A. Hyder (Advisor)

Prof. Laura Morlock

Dr. Lilly Engineer

Dr. Amber Mehmood

Dr. Aruna Chandran

Alternates: **Prof. David Celentano**

Conan Q. Dickson, PhD

ACKNOWLEDGEMENTS

I would like to thank my committee members (Prof. Adnan Hyder, Prof. Laura Morlock, Dr. Lilly Engineer, Dr. Amber Mehmood, and Dr. Aruna Chandran) for their input throughout the process. Your comments and feedback have sharpened and improved my ideas and approach. In particular, my advisor, Prof. Adnan Hyder, has provided endless support since the start of the project and for the development of this thesis. Special thanks goes to the faculty and staff of the Johns Hopkins Bloomberg School of Public Health, and particularly the faculty and staff of the Department of Health Policy and Management. It is a great pleasure and honor to be a student at the top school of public health in the world and to be given the opportunity to gain knowledge and skills that have launched my career as a public health advocate in Emergency Medicine! I am also thankful for my fellow members of the Abu Dhabi Cohort for their motivation and encouragement.

I would like to dedicate this work to my family—my parents, wife, and children—who sacrificed a lot to help me be the person I am today. Above all, I dedicate this degree to my beloved country, with sincere gratitude to His Highness Sheikh Mohamed bin Zayed Al Nahyan, the Crown Prince of Abu Dhabi, and Deputy Supreme Commander of the UAE Armed Forces, Chairman of the Executive Council of Abu Dhabi for his outstanding vision in sponsoring this MPH-DrPH cohort back in 2008, which provided a foundation for many leaders in the current healthcare system in Abu Dhabi.

The data on which this thesis is based is owned and hosted by the Department of Health (DOH) in Abu Dhabi, United Arab Emirates. The contents of this dissertation are solely the responsibility of the author and do not necessarily represent the official views of the Johns Hopkins Medical Institutions or the DOH.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF TERMS AND ABBREVIATIONS

ACS-COT: American College of Surgeons, Committee on Trauma

ADNOC: Abu Dhabi National Oil Company

ADTSI: Abu Dhabi Trauma System Initiative

CI: Confidence Interval

CSTR: Certified Specialist in Trauma Registry

DALYs: Disability-Adjusted Life Years

DOH: Department of Health

DQ: Data Quality

ED: Emergency Department

GBD: Global Burden of Diseases

GCS: Glasgow Coma Scale

ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification

IRB: Institutional Review Board

ISS: Injury Severity Score

LS: Length of Stay

MENA: Middle East and North Africa

MOI: Mechanism of Injury

MTOS: Major Trauma Outcome Study

NPTR: National Pediatric Trauma Registy

NTDB: National Trauma Data Bank

NTDS: National Trauma Data Standard

OR: Odds Ratio

RR: Respiratory Rate

RTI: Road Traffic Injuries

RTS: Revised Trauma Score

SBP: Systolic Blood Pressure

SCANTEM: UK, Germany and Scandinavian Networking Group for Trauma and Emergency Management

SD: Standard Deviation

SDGs: Sustainable Development Goals

SKMC: Sheikh Khalifa Medical City

STATA IC: Software for Statistics and Data Science

TARN: Trauma Audit and Research Network

TR-DGU: Trauma Register of the German Trauma Society

TISS: Trauma Injury Severity Score

WHO: World Health Organization

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND:

The trauma system is a key element of any emergency management system and was non-existent in the United Arab Emirates (UAE) until a few years ago [1]. A trauma-interested group in Abu Dhabi, consisting of Emergency physicians and Trauma Surgeons, decided to work on this crucial system with a belief that establishing such a system in Abu Dhabi will certainly help reduce mortality and morbidity as well as revolutionize trauma care in Abu Dhabi and the UAE.

In November 2010, I participated in establishing a trauma committee in coordination with the Abu Dhabi Health Authority to serve as a consultative forum to provide effective advice on current and future directions of the Trauma System in Abu Dhabi. This committee aimed to plan, organize, implement, and monitor the development of a state-of-the-art trauma system consisting of all components of a system, including: prevention; outreach and education; pre-hospital trauma care; inter-facility transfer; hospital organization and trauma programs; rehabilitation; trauma registry; performance and patient safety (PIPS) programs; upgrading rural trauma care; and finally, focusing on research and scholarship [2]. We firmly believed that building such a system would certainly boost the medical response capability within Abu Dhabi, address the daily demands of trauma care, and form the basis for disaster preparedness within our health system.

In Abu Dhabi, the DOH has identified trauma as one of the top 10 public health priorities because of its medical and economic impact. Trauma is the second leading cause of death in the UAE, which results in both physical and psychological impacts on patients, their families and society at large [3]. If there is no serious action, road traffic injuries are predicted to be the third leading contributor to the global burden of disease world-wide in 2020 and also will be the second leading determinant of disability-adjusted life years (DALYs) in the developing countires [4]. Much is being done and more can be done to reduce the incidence of trauma and its implications in the country. The infrastructure to address this public health issue requires resuscitation of all levels of our system. This should help in reducing the mortalities and morbidities and hence improving all trauma care.

Responding to the growing trauma problem and ever-increasing trauma care-related challenges, stakeholders including the Public Health and Research Division of the Department of Health; Zayed Military Hospital; major Abu Dhabi Health Services, Co.—SEHA (public sector) Facilities; Abu Dhabi Police Ambulance services; UAE University; and the Private Hospital Sector of Abu Dhabi developed a vision to address the issue of trauma care in the Emirate of Abu Dhabi and for the nation as a whole. The plan was to look at trauma as a "continuum" which begins with injury prevention and runs through rehabilitation services. This spectrum would cover all dimensions of care delivery and system performance.

To further this concept, the founding group organized their first meeting on November 10th, 2010 of representatives from all the major health facilities in Abu Dhabi with the purpose of creating an advisory committee to develop a "Trauma System" for the Emirate.

This meeting therefore was celebrated as the genesis of the Abu Dhabi Trauma System Initiative (ADTSI), one of the most important public health initiatives within the DOH. The basic components of a trauma system, adopted from the "Optimal Care of the Injured Victim 2006", were dissected and prioritized (Figure 1.1) according to the needs and personal experiences of the members of the team.

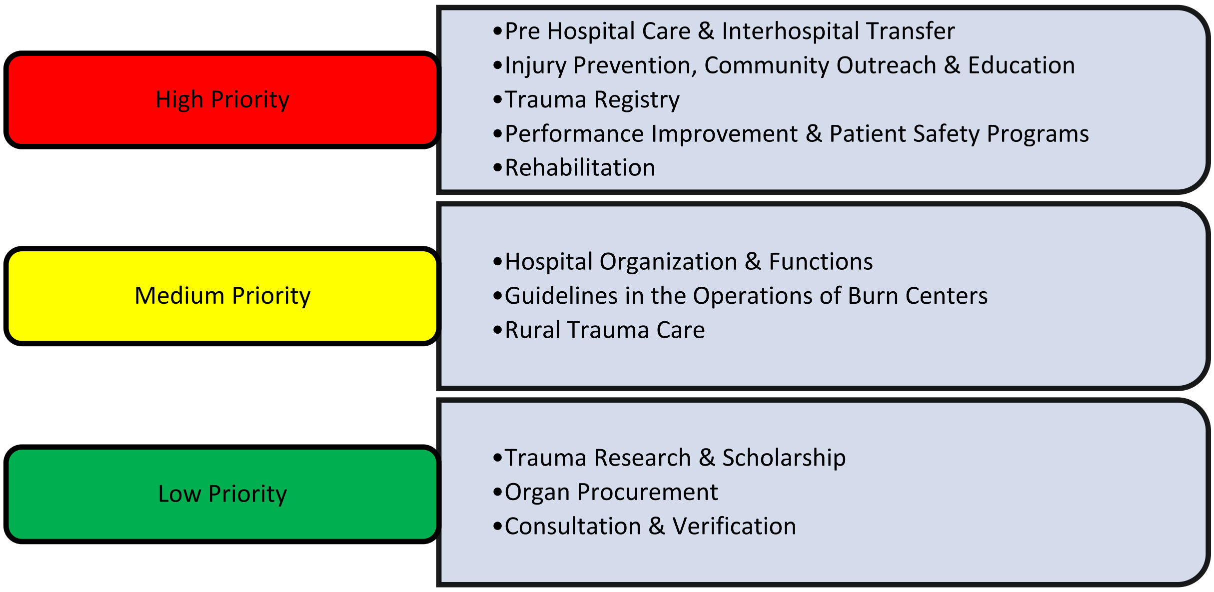


Figure 1.1 Trauma System Components Prioritized

As the Initiative gained traction and attracted a diverse set of interest groups, the different components were then assigned to sub-committees to further scrutinize all strategies and approaches that could possibly be implemented in Abu Dhabi. Membership was on a voluntary basis, initially depending on the area of expertise and interest. After the organization of subcommittees around different components, the members worked aggressively and voluntarily to create strategies in formulating the Trauma System in the Emirate. It was envisioned that there would be an insatiable desire for an organized Trauma System for the Emirate of Abu Dhabi whereby all the different aspects would integrate into a full system for the community.

The primary goal of a Trauma System is to diminish or eliminate the risk of death or permanent disability following traumatic events. Unfortunately, in many developing countries, a Trauma System is non-existent or, at best, skeletal. It is therefore essential to create awareness in the society about the Trauma System. Lessons learned from other developed countries in pursuing the enhancement of existing Trauma Systems have dramatically inspired the ADTSI as a whole. The true value of a Trauma System is derived from the seamless transition between each phase of care, integrating existing resources to achieve improved patient outcomes. The success of a Trauma System is largely determined by the degree to which it is supported by public policy and inspires the cooperation and integration of all stakeholders in pursuit of the need for a safer society [5–8].

As a cornerstone to the Trauma System, the ADTSI team, supported by DOH, worked with a constancy of purpose to establish the Abu Dhabi-centralized Trauma Registry—the first of its kind in the region. Introducing such a crucial tool is useful in gathering continuous standardized information which can be used to analyze and improve the quality of care for trauma patients and assist in the appropriate allocation of resources. Such information is also helpful in identifying common risk factors for different types of injuries and in targeting opportunities for intervention to reduce the incidence and overall burden of injury.

Specifically, this registry was developed to serve the following objectives: (1) to facilitate and improve patient care by rapidly locating and accurately reproducing significant amounts of clinical information relevant to the patient's present clinical problem; (2) to provide online clinical summaries of diagnostic and therapeutic methods; (3) to establish a data source for identifying risk factors for events and injuries; (4) to define the variables which correlate with patient morbidity and mortality; (5) to determine logistical and manpower requirements for a given community's trauma needs; and (6) to provide continuous monitoring of project planning for the care of the critically injured.

1.2 DISSERTATION AIMS AND OBJECTIVES:

The *overall goal* of this dissertation is to evaluate the efforts in developing the registry, identify opportunities for improvement, and provide the first summary of data on trauma and injuries to date. Specifically, we: (1) evaluated the quality of the registry and identified areas for improvement; (2) used the registry data to examine the epidemiology of trauma and outcomes in Abu Dhabi; and (3) studied the epidemiology of fall injuries in the registry. These efforts will be described in three chapters of this dissertation as follows:

Chapter 2 presents an evaluation of the data quality of the Abu Dhabi Trauma Registry using the Wang and Strong's conceptual model for measuring data quality (DQ) using six domains [9]. Here are several methods in the literature to evaluate data quality which are not widely used [10, 11]. But this model is considered one of the most widely accepted models for health care data. The research questions for this chapter are:

1. Are all necessary data provided in the registry? (Domain 1: Completeness)
2. Are the data matching patients' medical records? (Domain 2: Accuracy)
3. Are the data values specific? (Domain 3: Precision)
4. Are data within specific value domains? (Domain 4: Correctness)
5. Are data logical throughout data points? (Domain 5: Consistency)
6. Is the trauma registry available when required? (Domain 6: Timeliness)
7. Does the registry capture all injuries of interest to the trauma system? (Additional Domain: Coverage)

Chapter 3 presents the first description of the epidemiology and burden of trauma in Abu Dhabi. The specific objectives of this study are as follows:

1. To describe the trends and demographics of trauma over four years from seven facilities in Abu Dhabi.
2. To assess the characteristics and mechanisms of all trauma as well as work-related trauma.
3. To assess the factors associated with the length of stay among patients with trauma.
4. To assess the factors associated with mortality among patients with trauma.

The chapter addresses questions which are:

1. What are the characteristics of the involved patients?
2. What are the common mechanisms of trauma and how do these mechanisms vary by geographic area?
3. What are the most common types and severity of injuries and how do they correlate with different mechanisms of injury?
4. Based on the findings, are there any risk factors associated with these injuries?
5. What are the variations in key quality indicators of both pre-hospital and hospital care? (This will include hospital-based comparisons.)
6. What are some of the key outcome indicators?

Chapter 4 describes the epidemiology of falls from height in the Emirate of Abu Dhabi. The fall is one of the important injuries that gained attention recently after several injuries from falls. With the increasing development in the UAE, falls during construction remain one of the main concerns to public health providers especially since it was the highest cause of occupational deaths between 2008–2010, according to DOH (https://www.haad.ae/height-aware/). In 2012, the DOH launched a program called "Height Aware" to educate business owners, health and safety professionals, and workers about the risk of falls and improve the awareness around it. Chapter 4 describes a multi-centre, retrospective, observational study to assess the epidemiology and burden of falls in Abu Dhabi. The specific objectives of the study are as follows:

1. To describe the trends and demographics of falls over the past four years using data from seven facilities in Abu Dhabi.
2. To assess the characteristics and mechanisms of falls as well as work-related falls.

3. To assess the factors associated with the length of stay among patients who experienced falls.
4. To assess the factors associated with mortality among patients who experienced falls.

1.3 CURRENT STATE OF THE ABU DHABI TRAUMA REGISTRY:

The Trauma Registry is currently hosted securely by the Department of Health (DOH) and its development has leveraged the experience of other countries. Specifically, the structure of the database, data elements, and data definitions are modeled after the efforts of the American College of Surgeons, Committee on Trauma (ACS-COT) and its National Trauma Data Standard (NTDS), and the National Trauma Data Bank (NTDB). This modeling will allow us to benchmark our data with international data since trauma registries in many places around the world that have likewise adopted these standards. The registry has a part-time manager who meets with the participating hospitals on a monthly basis to discuss the project's status and overcome any challenges.

It is the objective of this dissertation to ensure that an accurate data collection is in place in order to quantify the "what's' & who's" in trauma care in the Emirate using a state-of-the-art Trauma Registry in collaboration with international partners. Nine facilities are part of the first phase of the implementation—Al Gharbia Hospital, Al Ain Hospital, Al Rahba Hospital, Mafraq Hospital, Sheikh Khalifa Medical City (SKMC) Hospital, Tawam Hospital, Al Noor Hospital, Abu Dhabi National Oil Company (ADNOC), and Zayed Military Hospital. After careful consideration of alternatives, the DOH decided to use software called the Collector™ developed by Digital Innovation, USA (Digital Innovation, Inc., Forest Hill, MD) to consistently collect data across these hospitals and aggregate the data for analysis by the DOH. Seven facilities out of the nine are involved in our study.

1.4 LITERATURE REVIEW:

1.4.1 Benefits of Trauma Registries:

The trauma registry has several known benefits documented in the literature. It is commonly used for quality improvement projects for trauma care within hospitals and/or in trauma systems as a whole. Such data is used for different purposes like designation and accreditation processes. It has also been documented that the introduction of the trauma registry helps in the reduction of mortality [12–14]. The data captured from the registry helps in benchmarking with different local and international data; furthermore, it can help in comparing hospital-to-hospital performance.

Another use of the trauma registry is the evaluation of clinical intervention(s). It can provide rich hospital and pre-hospital clinical data compared to the expensive randomized controlled trials and other research methods. The data from the registry helps in generating hypotheses, planning for protocols, and also recruiting candidates for trials. The large size of the registry helps in identifying rare injuries. An important benefit of the trauma registry is the help in shaping the prevention strategies. Although often not fully utilized, the data generated from the trauma registry can help in planning for community-specific and data-driven injury prevention campaigns.

For example, the Canadian National Registry and the Wisconsin state (USA) trauma care registry are serving as platforms for injury prevention plans [15, 16]. Examples of such plans include seat belt legislation. The pre-hospital care can tremendously benefit from the data included in any trauma registry. The controversial discussions around “stay and play” versus “scoop and run”, the golden hour, the advantages of pediatric referals to specialized centers, and bypass strategies to Level I trauma centers can all benefit from such data [17–19]. Furthermore, registry data helps in measuring the advantages of air transportation over ground in certain circumstances like rural areas [20, 21]. One last important benefit from the trauma registry is the ability to assess the post-discharge care and need for follow-up studies on quality of life [22, 23]. A good example is the Victorian State Trauma Registry (AU) which collects information on return to work and functional status for up to six months after the discharge. So, it is clear that the trauma registry is an important infrastructural component in establishing a robust trauma system. It provides a method of gathering and analyzing relevant epidemiological data which can be utilized for the purposes of quality improvement, research, and planning.

1.4.2 Development of Trauma Registries:

The earliest start of the computerized trauma registries was in 1969 at Cook County Hospital, Chicago [24]. It was a prototype for the Illinois Trauma Registry which became the main registry for more than 50 trauma centers in the state in 1971 [25]. The approach improved in 1985 by changing from using the bulky mainframe computer to microcomputer technology [26].

The American College of Surgeons Committee on Trauma (ACSCOT) commissioned the Major Trauma Outcome Study (MTOS) in 1982 to gather information about trauma patients and to develop and examine the survival probability norms using the injury severity scores [27]. The MTOS data were gathered retrospectively in four countries: the United States of America, Great Britain, Canada, and Australia. The variables used to generate the survival probability were the Injury Severity Score (ISS), the Revised Trauma Score (RTS), patient's age, and injury mechanism (TRISS methodology). Not too long ago, the ACS-COT founded the National Trauma Data Bank (NTDB) which is considered the largest aggregated collection of trauma data ever assembled and has more than one million records from over 400 trauma centers in the United States. It is continiously used to improve trauma care [28].

For the pediatric population, the National Pediatric Trauma Registy (NPTR) was developed as a collaboration among 80 hospitals which aimed to improve the care for this important population. The registry was able to gather over 100,000 records (1985–2003) which were reported on a voluntary basis [29].

Most of the countries in West Europe have some form of trauma registry. In the United Kingdom in 1990, more than 175 hospitals participated in a registry which was able to gather more than 27,000 patient records in 2010 (Trauma Audit and Research Network-TARN). The German Trauma Society was able to gather data from over 300 hospitals in 1993 (Trauma register of the German Trauma Society-TR-DGU). This initiative was further expanded when three groups (UK, Germany, and Scandinavian Networking Group for Trauma and Emergency Management – SCANTEM) were able to establish what was later called the European Trauma Registry Network. This was mainly focused on evaluating the Emergency Departments across Europe and building an infrastructure for comparison with international data, especially with the USA and Australia. Since then, the number of registries has increased in Europe and the total number of registered patients has reached 28,000 from over 600 participating hospitals in the Trauma Register DGU; this also includes 35 facilities in countries outside Germany like Austria, Slovenia, the Netherlands, Switzerland, Finland, Belgium, the United Arab Emirates (Rashid hospital in Dubai), and China. Other countries were able to establish trauma registries [30, 31], but it was difficult to sustain some of these efforts due to limited resources. Regionally, there has been several initiatives at local levels in Saudi Arabia, Pakistan, Qatar, and Iran, for example [32–35].

With all this development, obvious barriers have been identified including deficiencies in EMS care, inadequate communication, difficulties in the transportation of polytrauma patients, limited finances, lack of supporting governmental policies, lack of community cooperation, and the inability to analyze the data due to the lack of experienced epidemiologists, lack of funding, and the incomplete data; to mention few [31].

1.4.3 Models/Standards Proposed:

Implementing the Trauma Registry is a cornerstone of this project. A trauma registry usually gathers detailed information on the causality, nature, and severity of the injury. In general, trauma registries vary and mostly are limited to patients managed in major trauma centers, excluding deaths at the scene or minor injuires discharged from the hospitals (Table 1.1) [36]. The criteria used in Abu Dhabi is similar to the critieria from the National Trauma Data Bank User Manual.

Trauma Registry Inclusion Criteria

Includes at least 1 code within the range of the following injury diagnostic codes as defined in the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*

- 800-959.9

Excludes all diagnostic codes within the following code ranges:

- 905-909.9 (late effects of injury)
- 910-924.9 (superficial injuries, including blisters, contusions, abrasions and insect bites)
- 930-939.9 (foreign bodies)
-

And must also include 1 of the following criteria:

- Hospital admission

Or

- Patient transfer via emergency medical services transport (including air ambulance) from 1 hospital to another hospital

Or

- Death resulting from the traumatic injury (independent of hospital admission or hospital transfer status)

Table 1.1 Inclusion and Exclusion criteria used. Trauma Patient Definition. National Trauma Data Bank User Manual. October 2011

Although the terms used to describe "trauma centers" vary by region, they are described as levels I, II, III, or IV with Level I being the highest (Appendix A) [37]. This is based on the levels of resources available for the trauma patient, as well as the needs for research, prevention, and other support services. This variability can create large differences in the trauma data and therefore the ability to utlize such data. The differences may include: the type of data gathered (retrospective versus concurrent), the data variables, the methods used (computer versus filed repository), registrars' skills (trauma trainied versus health information specialist), the utilization of the data (performance improvement versus limited use), the size of the dataset, and finally whether the data are risk adjusted or not. Therefore, an effective registry will require sustainable funding, robust software, the creation of inclusion/exclusion criteria, well-trained staff, a clear process (for reporting and validation), and most importantly, the ability to maintain patients' confidentiality. Well-prepared staff can be assured through proper planning and training, which is available internationally and can result in certification (Certified Specialist in Trauma Registry, CSTR, as an example) [38, 39].

Some systems invest in either consultation help or a commercial solution. Maintaining a trauma database can be an expensive project and without a well-established foundation may result in an ineffective database which will certainly not help the objectives. Some of the well-known software products used in the world include: the Collector™ (Digital Innovation, Inc., Forest Hill, MD), Trauma One™ (Lancet Technology, Inc.), Trauma!™ (Cales and Associates, LLC, Louisville, KY), NATIONAL TRACS™ (American College of Surgeons), and TraumaBase™ (Clinical Data Management, Inc.).

1.4.4 Data Quality:

Over the past few decades, trauma registries contributed significantly to improving trauma care [40–42], but this depends heavily on data quality (DQ). Lack of such quality can affect patient decision processes and the quality of the evaluations [43–45]. Wang and Strong published a landmark conceptual model for measuring DQ, which became the most commonly used model to evaluate medical data [10]. The model describes DQ according to six dimensions: Completeness (all necessary data are provided), Accuracy (data match to a verifiable source), Precision (data value is specific), Correctness (data are within specific value domains), Consistency (data are logical throughout data points), and Timeliness (the availability of the trauma registry when required). A few recent analyses of the data quality of trauma registires suggest that the components of data completeness and data accuracy require more attention; they have been identified as the two most important variables in any data quality assessment [46, 47]. In a systematic review by Porgo et al., a rigourous literature search concluded that only a few research studies assessed the DQ in trauma registries, and these were mainly limited to the "completeness" aspect. The paper suggested that "a standardized, reproducible method to evaluate DQ in trauma registries based on all DQ dimensions and criteria to define DQ dimensions as poor, moderate, or good are needed" [48].

In 1995, Stewart et al. published a study in the *Journal of Trauma* to evaluate patients' outcomes before and after trauma center designation using trauma and injury severity score analysis [49]. They compared injury outcomes in the main trauma hospital in Southwest Ontario, Canada before and after its trauma center designation, which was associated with better government support and increased infrastructure. The study concluded that trauma center designation resulted in improved outcomes. In a comprehensive systematic review of trauma system effectiveness based on registry comparisons, Mann et al. presented comparable data which consistently showed 15 to 20% decreases in the risk of death when comparing trauma system outcomes to MTOS norms [50]. Despite the differences in the systems across the world, there are impressive similarities in the associations observed of resource commitment and trauma system designation with decreased mortality and morbidity compared with national reference standards.

In summary, given the numerous models for trauma registries world-wide, there is a growing body of literature to support our project and to ensure the project is meeting international standards, including the operational aspects and the DQ. The lessons from our experience will be shared with the scientific community and hopefully will help similar initiatives elsewhere.

1.5 THE CONCEPTUAL FRAMEWORK:

The conceptual framework of this project, as mentioned in the literature review, focuses on introducing a robust trauma registry, which is a cornerstone in establishing a trauma system, that will better organize existing data from different facilities and improve trauma infrastructure. Organizing the data will help us understand the pattern of trauma in the Emirate of Abu Dhabi (i.e., the magnitude of the problem), as well as compare the care in Abu Dhabi to comparable data from the National Trauma Data Bank® (NTDB®), the largest aggregation of the United States trauma registry data ever assembled, thus enabling us to set better strategies to care for the trauma patients. These activities will eventually improve the outcomes of the trauma patients in the Emirates of Abu Dhabi (Figure 1.2).

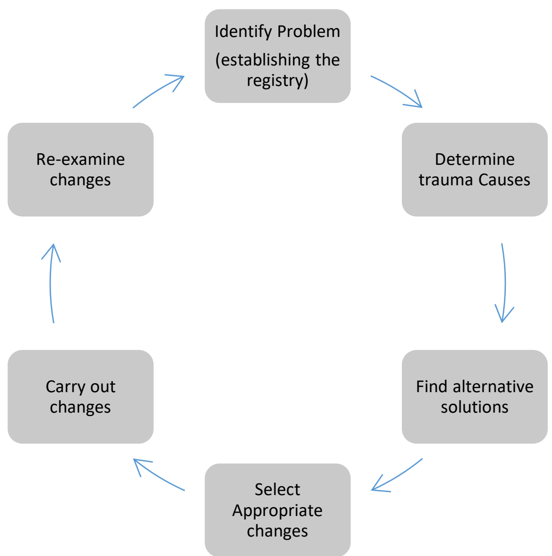


Figure 1.2 Conceptual Framework of the Project

1.6 CONCLUSION:

This dissertation will enable local trauma experts and policy makers to be able to evaluate trauma as a public health problem and also to be able to tailor specific interventions to decrease the mortality and the morbidity of victims and eventually improve the outcomes of trauma care in the Emirate. This will hopefully also influence the regional trauma care, as there is a significant interest in the region but limited data and publications from which to learn. In order to further improve trauma care in Abu Dhabi, we also anticipate a better governmental investment in the emergency care sector.

1.7 REFERENCES:

1. *Fares, S., Irfan, F. B., Corder, R. F., Al Marzouqi, M. A., Al Zaabi, A. H., Idrees, M. M., & Abbo, M. (2014). Emergency medicine in the United Arab Emirates. International journal of emergency medicine, 7(1), 4.*
2. *Sobel, J., Khan, A.S., Swerdlow, D.L., 2002. "Threat of a biological terrorist attack on the US food supply: the CDC perspective." Lancet 359, 874–880*
3. *HAAD Annual Report 2010. http://www.haad.ae/haad/2010_English%20HAAD%20Annual%20Report/ Accessed on March 6, 2016.*
4. *Murray CJ, Lopez AD: Alternative projections of mortality and disability by cause 1990–2020: Global Burden of Disease Study. Lancet 1997, 349(9064):1498-1504.*
5. *Shafi S, Nathens AB, Elliot AC, Gentilello L. Effect of trauma systems on motor vehicle occupant mortality: a comparison between states with and without a formal system. J Trauma 2006;61:1374–9*
6. *Lansick KW, Leenen LP. Do designated trauma systems improve outcome? Curr Opin Crit Care 2007;13:686–90*
7. *Mock C, Juillard C, Brundage S, Goosen J, Joshipura M. Guidelines for trauma quality improvement programmes. Geneva: World Health Organization; 2009 http://whqlibdoc.who.int/publications/2009/9789241597746_eng.pdf*
8. *Cameron PA, Gabbe B, Cooper DJ. A statewide system of trauma care in Victoria: effect on patient survival. Med J Aust 2008;189:546–50*
9. *Wang RY, Storey VC, Firth CP. A framework for analysis of data quality research. IEEE Transactions on Knowledge and Data Engineering. 1995;7(4): 623-640*
10. *D.M. Strong, Y.W. Lee, and R.Y. Wang, Beyond Accuracy: How Organizations Are Redefining Data Quality, 1994*

11. *R.Y. Wang, D.M. Strong, and L.M. Guarascio, Beyond Accuracy: What Data Quality Means to Data Consumers, 1994*

12. *Pollock DA. Summary of the discussion: trauma registry data and TRISS evidence. J Trauma 1999;47(3 Suppl):S56–8.*

13. *Moore L, Clark DE. The value of trauma registries. Injury. 2008;39(6):686–95.*

14. *Rutledge R. The goals, development, and use of trauma registries and trauma data sources in decision making in injury. Surg Clin North Am. 1995;75(2):305–26*

15. *National Trauma Registry. Available at: http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=services_ntr_e (accessed on March 26, 2016).*

16. *Wisconsin Trauma Care Registry. Available at: http://www.ncrtac-wi.org/index.php?id=140,0,0,1,0,0 (accessed on March 26, 2016).*

17. *Hartl R, Gerber LM, Iacono L, et al. Direct transport within an organized state trauma system reduces mortality in patients with severe traumatic brain injury. J Trauma 2006;60(6):1250–6 [discussion 1256].*

18. *Nathens AB, Maier RV, Brundage SI, et al. The effect of interfacility transfer on outcome in an urban trauma system. J Trauma 2003;55(3):444–9.*

19. *Rogers FB, Osler TM, Shackford SR, et al. Study of the outcome of patients transferred to a level I hospital after stabilization at an outlying hospital in a rural setting. J Trauma 1999;46(2):328–33.*

20. *Mitchell AD, Tallon JM, Sealy B. Air versus ground transport of major trauma patients to a tertiary trauma centre: a province-wide comparison using TRISS analysis. Can J Surg 2007;50(2):129–33.*

21. *Ringburg AN, Spanjersberg WR, Frankema SP, et al. Helicopter emergency medical services (HEMS): impact on onscene times. J Trauma 2007;63(2):258–62.*

22. *Gabbe BJ, Cameron PA, Finch CF. Is the revised trauma score still useful? Aust NZ J Surg 2003;73(11):944–8.*

23. *Jakola AS, Muller K, Larsen M, et al. Five-year outcome after mild head injury: a prospective controlled study. Acta Neurol Scand 2007;115(6):398–402.*

24. *Boyd DR, Rappaport DM, Marbarger JP, Baker RJ, Nyhus LM: Computerized trauma registry: a new method for categorizing physical injuries. Aerosp Med 1971, 42(6):607-615.*

25. *Cales RH, Bietz DS, Heilig RW Jr: The trauma registry: a method for providing regional system audit using the microcomputer. J Trauma 1985, 25(3):181-186.*

26. *Shapiro MJ, Cole KE Jr, Keegan M, Prasad CN, Thompson RJ: National survey of state trauma registries – 1992. J Trauma 1994, 37(5):835-840. discussion 840–832*

27. *Champion HR, Copes WS, Sacco WJ, Lawnick MM, Keast SL, Bain LW Jr, Flanagan ME, Frey CF: The Major Trauma Outcome Study: establishing national norms for trauma care. J Trauma 1990, 30(11):1356-1365.*

28. *American College of Surgeons Committee on Trauma. National Trauma Data Bank (NTDB) [http://www.facs.org/trauma/ntdb.html]. Accessed: March 27,2016*

29. *Tepas JJ 3rd: The national pediatric trauma registry: a legacy of commitment to control of childhood injury. Semin Pediatr Surg 2004, 13(2):126-132.*

30. *Schultz CR, Ford HR, Cassidy LD, Shultz BL, Blanc C, King-Schultz LW, et al. Development of a hospital-based trauma registry in Haiti: an approach for improving injury surveillance in developing and resource-poor settings. J Trauma. 2007; 63(5):1143-54.*

31. *Nwomeh BC, Lowell W, Kable R, Haley K, Ameh EA. History and development of trauma registry: lessons from developed to developing countries. World J Emerg Surg. 2006; 1:32.*

32. *Al-Naami, M. Y., Arafah, M. A., & Al-Ibrahim, F. S. (2010). Trauma care systems in Saudi Arabia: an agenda for action. Annals of Saudi medicine, 30(1), 50.*
33. *Alyafei, K. A., Toaimah, F., El Menyar, A., Al Thani, H., Youssef, B., Mollazehi, M., & Consunji, R. (2015). Analysis of pediatric trauma data from a hospital based trauma registry in Qatar. International journal of critical illness and injury science, 5(1), 21.*
34. *Zargar, M., Motamedi, S. M. R. K., Karbakhsh, M., Ghodsi, S. M., Rahimi-Movaghar, V., Panahi, F., ... & Khodabandeh, M. (2011). Trauma care system in Iran. Chinese Journal of Traumatology (English Edition), 14(3), 131-136.*
35. *Mehmood, A., & Razzak, J. A. (2009). Trauma registry needs and challenges in developing countries.*
36. *Inclusion and Exclusion criteria used. Trauma Patient Definition. National Trauma Data Bank User Manual. October 2011*
37. *Sasser, S. M., Hunt, R. C., Sullivent, E. E., Wald, M. M., Mitchko, J., Jurovich, G. J., ... & Cooper, A. (2009). Guidelines for field triage of injured patients: recommendations of the National Expert Panel on Field Triage.*
38. *Report from the 1988 Trauma Registry Workshop, including recommendations for hospital-based trauma registries. J Trauma 1989, 29(6):827-834.*
39. *National survey of trauma registries – United States, 1987. MMWR Morb Mortal Wkly Rep 1989, 38(49):857-859.*
40. *Stelfox HT, Bobranska-Artiuch B, Nathens A, Straus SE. Quality indicators for evaluating trauma care: a scoping review. Arch Surg. 2010; 145(3):286-295*
41. *Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. J Trauma. 1999;47(Suppl 3): S46-S55.*

42. *Mackenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, Salkever DS, Weir S, Scharfstein DO. The national study on costs and outcomes of trauma. J Trauma. 2007;63(Suppl 6):S54-S67; discussion S81-S86.*
43. *Pronovost PJ, Miller M, Wachter RM. The GAAP in quality measurement and reporting. JAMA. 2007;298(15):1800-1802.*
44. *Hlaing T, Hollister L, Aaland M. Trauma registry data validation: essential for quality trauma care. J Trauma. 2006;61(6):1400-1407.*
45. *O'Donoghue J, O'Kane T, Gallagher J, Courtney G, Aftab A, Casey A, Torres J, Angove P. Modified early warning scorecard: the role of data/information quality within the decision making process. The Electronic Journal of Information Systems Evaluation. 2011;13(3):100-109.*
46. *Mashoufi M, Ayatollahi H, Khorasani-Zavareh D. A review of data quality assessment in emergency medical services. The open medical informatics journal. 2018;12:19.*
47. *Juddoo S, George C. Discovering the most important data quality dimensions in health big data using latent semantic analysis.*
48. *Porgo, T. V., Moore, L., & Tardif, P. A. (2016). Evidence of data quality in trauma registries: a systematic review. journal of trauma and acute care surgery, 80(4), 648-658.*
49. *Stewart, T. C., Lane, P. L., & Stefanits, T. (1995). An evaluation of patient outcomes before and after trauma center designation using trauma and injury severity score analysis*
50. *Mann, N. C., Mullins, R. J., MacKenzie, E. J., Jurkovich, G. J., & Mock, C. N. (1999). Systematic review of published evidence regarding trauma system effectiveness. Journal of Trauma and Acute Care Surgery, 47(3), S25-S33.*

51. *Bray F, Parkin DM. Evaluation of data quality in the cancer registry: principles and methods. Part I: comparability, validity and timeliness. Eur J Cancer. 2009;45(5):747-755.*

52. *Centers for Disease Control and Prevention. National program of cancer registries. National program of cancer registries program standards,2012-2017. Updated January 2013. Available at: http://www.cdc.gov/cancer/npcr/pdf/npcr_standards.pdf. Accessed July 3, 2017.*

53. *Oyetunji, T. A., Crompton, J. G., Ehanire, I. D., Stevens, K. A., Efron, D. T., Haut, E. R., ... & Haider, A. H. (2011). Multiple imputation in trauma disparity research. Journal of surgical research, 165(1), e37-e41.*

CHAPTER 2: EVALUATION OF THE DATA QUALITY OF THE ABU DHABI TRAUMA REGISTRY

2.1 ABSTRACT

2.1.1 Background

Trauma registries have unparalleled significance in health systems as they provide endless opportunities to produce available data and to analyze a range of health outcomes; however, the creation and maintenance of such databases is challenging. The valid use of trauma registries hinges on data quality. In this study, we aim to assess the data quality of the trauma registry using the data extracted from the seven facilities in Abu Dhabi collected between 2014 and 2017 using the Wang and Strong framework.

2.1.2 Methods

Data quality indicators from seven facilities in Abu Dhabi entered into the registry between 2014 and 2017 were extracted from the registry and data quality was assessed using the six domains from the Wang and Strong' framework including: *Completeness*; *Accuracy*; *Precision*; *Correctness*; *Consistency*; and *Timeliness*. An additional domain of "*Coverage*" was also assessed. The data quality was assessed using a set of 14 pre-selected variables.

2.1.3 Results

Starting from a total of 20,562 cases, after excluding 2,735 cases, a random sample of 5% was selected from the remaining 17,827 cases and the data quality was assessed on a sample of 891 cases. For *Completeness*, data was 100% complete for variables including age and gender. Among all the 14 variables, *Completeness* ranged between 99.8% for Hospital Discharge Disposition and 54% for trauma and injury severity score (TRISS). Overall data *Accuracy* ranged between 90.6% and 99.16%. Overall *Concordance* ranged from 95% to

almost 100%. For *Correctness*, the imputation process is automated and consistent with the edit rules and the built-in processes in the registry of American College of Surgeons (ACS) standards. For *Consistency*, all data elements were consistent within the data dictionary and conformed to data dictionary standards. For *Timeliness*, about 70% of the overall data was entered within 60 days while 73% of the data was entered within 90 days. On a per-facility basis, data entry within 60 days ranged between 5% and 92% while that within 90 days ranged between 11% and 97%. Overall, the minimum time to close was within the same day of entry while the maximum time to close was about 4.5 years. For *Coverage*, currently the data registry is comprised of data from the seven facilities in Abu Dhabi; 100% coverage will eventually be achieved once the registry expands to other health institutes in Abu Dhabi.

2.1.4 Conclusion

This study presents the first analysis of the Abu Dhabi Trauma Registry data since the establishment in 2014, which provides insight on the data quality. Overall, the Abu Dhabi trauma registry has an acceptable quality with certain areas for improvement. Such important findings will help plan and implement future policies related to trauma prevention and management in the Emirate of Abu Dhabi specifically and the region as a whole.

2.2 INTRODUCTION

2.2.1 Introduction

Trauma has become a major public health concern with almost 5 million deaths world-wide attributable to trauma in 2016 [1]. According to the Global Burden of Diseases (GBD), Injuries, and Risk Factors study, approximately 973 million people sustained trauma that warranted some type of healthcare in 2013 [2]. Globally, the total deaths from trauma increased by 2.3% between 2007 and 2017, while the death rate decreased by 13.7% to 57.9 deaths per 100,000 in 2017 [3]. Over the past few decades, trauma registries have contributed significantly to improving trauma care [4–6], and this has increasingly become more imperative with the adoption of the UN's Sustainable Development Goal number three, directly targeting the reduction of global deaths and injuries from road traffic accidents. However, there is a scarcity of trauma registries in the Middle East [7, 8] and the situation is further complicated by the fact that the existing data collection efforts are prone to negligence and underreporting [7, 9].

2.2.2 Rationale and Importance of a Trauma Registry

Trauma registries are databases that collect key information regarding trauma patients. The major objective of this repository of information is to assess and improve the efficiency and quality of trauma care at the trauma units or facilities [10]. It is commonly used for quality improvement projects for trauma care within hospitals and/or in trauma systems as a whole. Such data may also be used for different purposes like designation and accreditation processes. The data captured in the registry helps in benchmarking for comparison with different local and international data; furthermore, it can help in comparing hospital-to-hospital performance.

Another use of the trauma registry is the evaluation of clinical interventions. It can provide rich hospital and pre-hospital clinical data. The data from the registry help in generating hypotheses, planning for protocols, and also recruiting candidates for trials. An important benefit of the trauma registry is the help it provides in shaping the prevention strategies. Although often not fully utilized, the data generated from the trauma registry can help in planning for community-specific and data-driven injury prevention campaigns.

Although the trauma registries have unparalleled significance in health systems as they provide endless opportunities to produce available data and to analyze a range of health outcomes, the creation and maintenance of such databases is challenging [11]. Setting up and maintaining trauma registries requires a substantial investment of money, time, and effort. Moreover, trauma registries in some facilities might not offer a true population-level representation due to differences in case inclusion and exclusion criteria, varying data content, and limited geographic and population coverage [12]. Completeness and quality of the data registries might also vary and consequently limit the utility of trauma registries [10, 12]. Evidence from existing trauma registries suggests that amongst the small number of trauma registries in developing countries, there is a large variation in processes for data collection [13]. Existing trauma registries might also differ based on the type of data limits, the methods used (computer versus physically filed repository), registrars' skills (trauma trained versus health information specialist), the utilization of the data (performance improvement versus limited use), the size of the dataset, and finally whether the data are risk adjusted or not.

2.2.3 Data Quality in Trauma Registries

The valid use of trauma registries hinges on data quality [14, 15]. A systematic review assessing the level of reporting of data completeness and the methods used to deal with missing data, compiled using trauma registry data, suggests that most manuscripts using trauma registry data did not quantify the extent of missing data for any variables and contained minimal discussion regarding their absence [16]. Another review suggested that the most commonly reported data quality measure was completeness. The review also highlighted the need to develop a standardized and reproducible method to evaluate data quality in trauma registries and explore other quality indicators [17].

In 1994, Wang and Strong published a landmark conceptual model for measuring data quality which became the most commonly used model to evaluate medical data [18]. The model describes data quality according to six dimensions:

1. Completeness (all necessary data are provided);
2. Accuracy (data match a verifiable source);
3. Precision (data value is specific);
4. Correctness (data are within specific value domains);
5. Consistency (data are logical throughout data points); and
6. Timeliness (the availability of the trauma registry when required).

For this study, we aim to assess the data quality of the existing trauma registry in use by seven facilities in Abu Dhabi between 2014 and 2017 using the Wang and Strong framework. We have added an additional domain of "*Coverage*" to our study in order to assess the representativeness, and potential generalizability, of the analysis results.

2.2.4 History of the Abu Dhabi Trauma Registry

In 2010, a trauma committee was established under the umbrella of the Department of Health (DOH) in Abu Dhabi to provide advice on the current and future directions of the Trauma System there and they successfully established the Abu Dhabi-centralized Trauma Registry. The registry was modeled on the standards of the American College of Surgeons Committee on Trauma (ACS-COT) Trauma Registry System. The DOH decided to use a piece of software called the Collector™ developed by Digital Innovation, USA (Digital Innovation, Inc., Forest Hill, MD) to consistently collect data across the selected hospitals and aggregate the data for analysis by the DOH. This data registry was the first of its kind in the region to collect data on trauma patients from multiple facilities in Abu Dhabi.

Currently, the Trauma Registry is securely hosted by the DOH, who shared this experience with a few countries in the region to help develop similar registries. Specifically, the structure of the database, data elements, and data definitions are modeled after the efforts of the ACS-COT and its National Trauma Data Standard (NTDS) and the National Trauma Data Bank (NTDB). Currently, qualifying cases are collected and uploaded into the Trauma Registry website (https://trauma.doh.gov.ae/) by each hospital. The respective trauma directors and managers are responsible for maintaining good quality data entry.

The aim of this study is to evaluate the data quality of the Abu Dhabi Trauma registry using data from seven hospitals between the periods of 2014 to 2017. For this study, we have utilized data from the existing trauma registry of seven facilities in Abu Dhabi collected between 2014 and 2017. This analysis will enable organizers and policy makers to learn more about the magnitude of trauma in Abu Dhabi and lead to a better understanding of the strengths and weaknesses of the current practices.

2.3 METHODS

2.3.1 Objectives

The primary objective of this study was to evaluate the quality of the data registry from seven facilities in Abu Dhabi and identify areas for improvement based on the following six domains, outlined by the Wang and Strong framework, plus one additional domain:

1. Completeness (all necessary data are provided);
2. Accuracy (data match a verifiable source);
3. Precision (data value is specific);

4. Correctness (data are within specific value domains);
5. Consistency (data are logical throughout data points); and
6. Timeliness (the availability of the trauma registry when required).
7. Coverage (to ensure that the registry captures all injuries of interest to the trauma system using practices of the NTDB)

2.3.2 Study Design

This was a retrospective observational study based on data from the trauma registries of seven facilities in Abu Dhabi.

2.3.3 Study Settings

Data to determine quality indicators from seven facilities in Abu Dhabi collected between 2014 and 2017 were extracted from the registry. The total numbers of beds in these facilities were 2,551; one facility had fewer than 200 beds; two facilities ranged between 201 and 400 beds; three facilities ranged between 401 and 600 beds; and one facility had over 600 beds. Five facilities were public; one facility was private; and one was a military facility. According to the Abu Dhabi regions, two facilities were on Abu-Dhabi Island; two from the Abu Dhabi Region; one was from the Eastern Region; and two were from the Al Dhafra Region. For details on the facilities, please refer to Table 2.1.

Facility Characteristic	***Number (%)***
No. of hospitals submitted data	7
No. of facilities by bed size:	
< 200	1 (14.2%)
201–400	2 (28.5%)

401–600 >600	3 (42.8%) 1 (14.2%)
Total number of beds	2551
Types of facilities Public facilities Private facilities Military facility	 5 (71.4%) 1 (14.2%) 1 (14.2%)
Facilities by region: Abu-Dhabi Island Abu-Dhabi Region Eastern Region Al-Dhafra Region	 2 (28.5%) 2 (28.5%) 1 (14.5%) 2 (28.5%)

Table 2.1 Facility Information

2.3.4 Data Gathering and Analysis

This study focuses on data which were retrospectively collected using the COLLECTOR Registry from January 1, 2014 to December 31, 2017 across the seven participating facilities. We evaluated the data quality of the Abu Dhabi Trauma Registry using the six domains from the Wang and Strong' framework [18] plus the additional domain of *Coverage*. The data quality was assessed using the pre-selected variables defined in Table 2.2.

Variables	***Variable Definitions***
Age	Indicates the patient's age on the arrival date to the emergency department (ED). It is automatically calculated by Collector if date of birth is entered, using DOB and the ED arrival date.
Race	The race of the patient as stated by the patient or next of kin.
Gender	The gender of the patient.
First Emergency Department Glasgow Coma Score (1st ED GCS)	First recorded Glasgow Coma Score (total) within 30 minutes or less of ED/hospital arrival.

First Emergency Department Respiratory Rate (1st ED RR)	First recorded respiratory rate in the ED/hospital within 30 minutes or less of ED/hospital arrival (expressed as a number per minute).
First Emergency Department Systolic Blood pressure (1st ED SBP)	First recorded systolic blood pressure in the ED/hospital, within 30 minutes or less of ED/hospital arrival.
Emergency Department Discharge Disposition (Post ED Disp.)	The disposition of the patient when discharged from the emergency department.
Respiratory level (Resp. Level)	Indicates whether the patient left the emergency department intubated.
Injury Severity Score (ISS)	The Injury Severity Score (ISS) is a summary score for traumatic injuries The ISS is calculated as the square of the Abbreviated Injury Scale (AIS).
Mechanism of Injury	Mechanism of injury is defined as the cause of injury.
E-Codes	The main, external cause of the injury, assigned on the basis of the most severe injury.
TRISS	TRISS is a method used to estimate probability of survival as a function of ISS, revised trauma score (RTS), patient age, and type of injury (blunt or penetrating), using a logistic model.
ICD-9 Injury Diagnosis (ICD9 Dx)	Diagnoses related to all identified injuries
Hospital Discharge Disposition (DC Disp.)	The disposition of the patient when discharged from the hospital.

Table 2.2 Variables used to assess accuracy and completeness of the trauma registry data and respective definitions

Data were collected on these variables from 5% of a randomly selected sample from the registry and compared with the medical records. The six domains of the Wang and Strong' frameworks are defined below:

1. ***Completeness***: assessed by evaluating whether key variables were successfully completed, including age, sex, Systolic Blood Pressure (SBP), Respiratory Rate (RR), and the Glasgow Coma Scale (GCS).

2. ***Accuracy***: assessed by comparing a sample from the data registry with the medical records from each facility.

3. ***Precision****:* assessed by reviewing the data to see if the data values were specific.

4. ***Correctness****:* assessed by checking that the data were within specific value domains.

5. ***Consistency***: evaluated by several observations like recording pregnancy status in males, having a greater Emergency Department (ED) length of stay (LOS) than hospital LOS, the arrival date after the admission date, or a discharge date from before the admission date.

6. ***Timeliness****:* assessed by evaluating whether all observations were completed within 90 days.

7. ***Coverage****:* An additional domain was added to ensure that the registry captures all injuries of interest to the trauma system using practices of the NTDB.

For each facility, a team made up of independent evaluators (one doctor, one nurse) independently re-abstracted the data and evaluated the aforementioned domains using a standardized electronic form which was generated to capture all key aspects of the data quality assessment. The teams underwent a standardized training by the principal investigators. Direct communication was established with the teams to ensure a smooth process.

Statistical analysis was performed using STATA IC version 16 and Excel. Dichotomous data are presented as frequencies and percentages while continuous data are presented as means and standard deviations (SD).

2.3.5 Institutional Review Board (IRB) Approval

Institutional Review Board (IRB) Approval for the study was obtained from the Zayed Military Hospital Institutional Review Board (IRB) to use the data from the trauma registry. We also obtained administrative approval from the DOH.

2.4 RESULTS

These results summarize data quality from the Abu Dhabi Trauma Registry. A total of 20,562 trauma cases were identified from the trauma registries; data was excluded for 2,664 cases from those facilities which were unable to participate in the study; data for 71 cases were excluded since the data was incomplete. A random sample of 5% was selected from 17,827 remaining cases and the data quality was assessed on a sample of 891 cases (Figure 2.1).

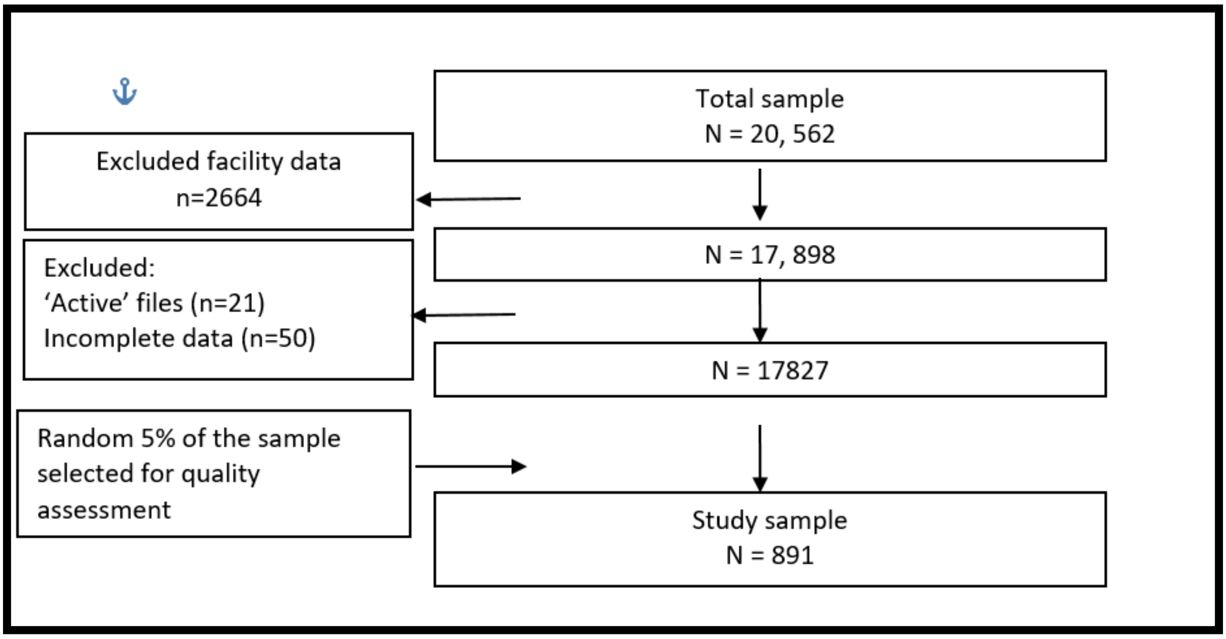


Figure 2.1 Study Flow of Participants

2.4.1. Completeness

The domain of *Completeness* assessed whether all necessary data was provided and this was determined by evaluating whether key variables were successfully completed, including age, sex, SBP, RR, and the GCS. Data was 100% complete for variables including age and gender. Completeness was 99.8% for DC. Disp.; completeness was 99.7% for Mechanism of Injury (MOI); completeness was 99.2% for post ED disposition; completeness was 99.1% for E-Codes and ICD9 DX; completeness was 99% for ISS; completeness was 97.4% for Resp.

levels; completeness was 96.6% for race; completeness was 96.5% for 1st ED RR; completeness was 95.4% for 1st ED GCS. For 1st ED SBP, completeness was found to be 84.6% with 5.5% data not specified and 9.9% data unknown. For TRISS, completeness was 54%, with 46% of the data not specified. Figure 2.2 summarizes the overall completeness of the data for each variable while facility-specific completeness of data for each variable is summarized in Appendix Figure 1.

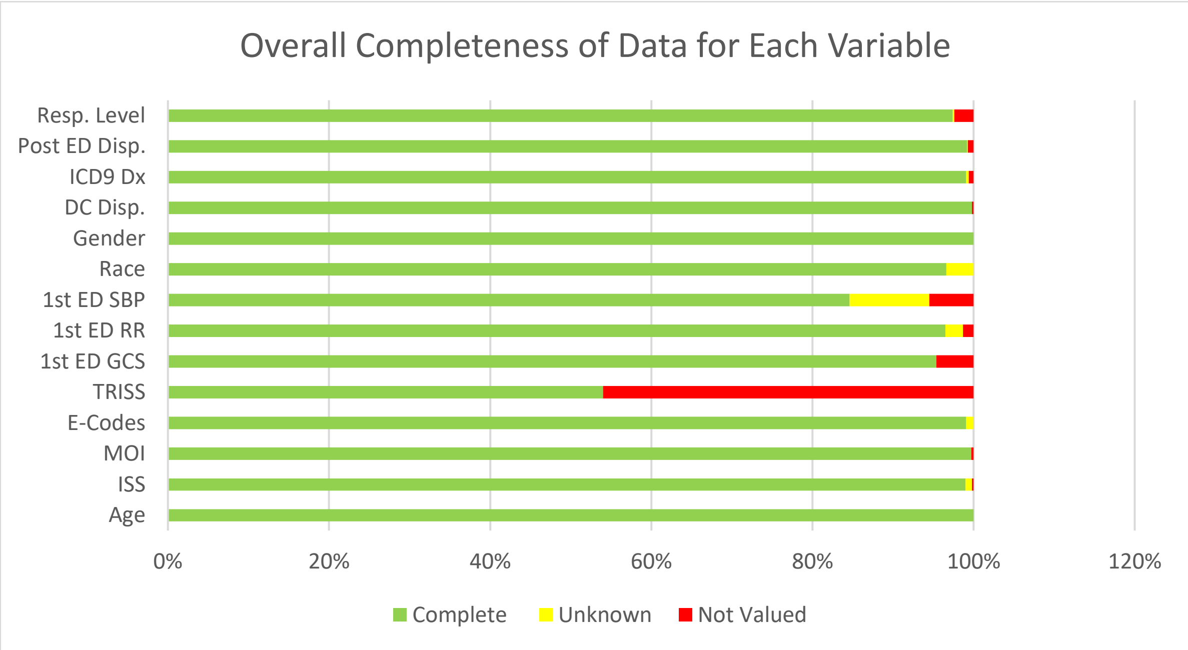


Figure 2.2 Overall Completeness of Data for Each Variable

2.4.2 Accuracy

The domain of *Accuracy* assessed whether the data matched a verifiable source. In order to assess accuracy, we compared a random sample from the registry with the medical records from each facility. Accuracy ranged between 90.6% and 99.16%. Table 2.3 depicts the overall data accuracy.

Facility	Trauma Registry Entries	Validated Files	%	Validity Rate
A	4,779	264	5.50%	97.85%
B	1,234	90	7.00%	96.39%
C	2,411	298	12.40%	99.16%
D	263	24	8.80%	91.93%
E	5,321	276	5.20%	99.65%
F	3,427	182	5.29%	97.78%
G	392	21	5.30%	90.60%
Total	17,827	1155	6.47%	96.19%

Table 2.3 Overall Data Accuracy

2.4.3 Precision

Precision was assessed by reviewing the data compared to the patients' medical records to see if the data values were specific. Precision could not be assessed for E-Code, ISS, or TRISS since these variables are auto-calculated in the registry based on data entered on pre-existing variables. For all other variables, concordance ranged from 95% to almost 100%. Table 2.4 and Figure 2.3 summarize the concordance and discordance for each of the variables.

Variables	*Total Sample (N)*	*Percentages (Numbers)*		
		Concordance	*Deviation*	*Verification not possible*
Age	891	99.7% (888)	0.3% (3)	0%
Mechanism of Injury	891	98.5% (878)	1.5% (13)	0%
First Emergency Department Glasgow Coma Score (1st ED GCS)	891	98% (873)	2% (18)	0%
First Emergency Department Respiratory Rate (1st ED RR)	891	98.8% (880)	1.2% (11)	0%
First Emergency Department Systolic Blood pressure (1st ED SBP)	891	98.1% (874)	1.9% (17)	0%

Race	891	98.7% (879)	1.3% (12)	0%
Gender	891	99.9% (890)	0.1% (1)	0%
Hospital Discharge Disposition (DC Disp.)	891	99.7% (888)	0.3% (3)	0%
ICD-9 Injury Diagnosis (ICD9 Dx)	891	94.73% (844)	5.27% (47)	0%
Emergency Department Discharge Disposition (Post ED Disp.)	891	99.7% (888)	0.3% (3)	0%
Respiratory level (Resp. Level)	891	97.97% (873)	2.03% (18)	0%

Table 2.4 Data Precision

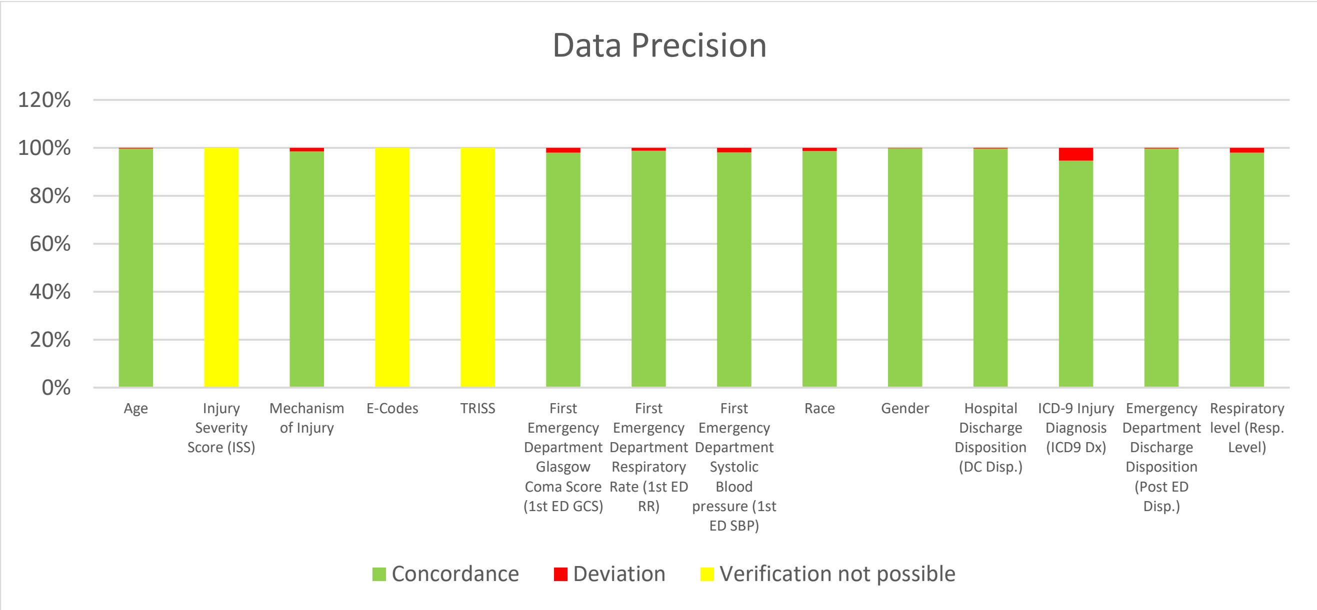


Figure 2.3 Data Precision

2.4.4 Correctness

Correctness was assessed through checking that the data were within specific value domains (e.g., vitals signs were within physiological ranges). Standard data submission procedures existed and were followed by data providers.

Data-capture quality control measures exist and were implemented by data providers according to the American College of Surgeons recommendation. Validity checks are done by the registrars for each data element and any invalid data are flagged. Edit rules and imputation are logical and applied consistently. The registry auto-calculates the following three variables based on some of the other added parameters:

1. Injury severity score

2. E-CODES

3. TRISS

The imputation process is automated and consistent with the edit rules and the built-in processes in the registry, which were based on the ACS standards.

2.4.5 Consistency

Consistency was assessed by confirming that the data were logical throughout data points. This was evaluated via several observations such as recording the pregnancy status of males, having a greater ED LOS than hospital LOS, the arrival date being recorded after the admission date, or the discharge date being recorded before the admission date. All data elements were found to be consistent within the data dictionary and to conform to data dictionary standards. Data were collected at the finest level of detail practical while for any derived data element, the original data element remained accessible (electronically or on paper). Data were collected using a consistent time frame, especially between and within jurisdictions, and identifiers were used to differentiate facilities or organizations uniquely for historical linkage. Documentation on historical changes to the data existed and was easily accessible.

2.4.6. Timeliness:

The domain of *Timeliness* meant that the trauma registry was available when required, which was documented using the experience of trauma registry users in Abu Dhabi. This means that all observations should have been completed in the registry within one year of the end of the diagnosis year/last fiscal year. We found that the majority of data from each facility was entered within 60 days or 90 days. Overall, 70% of the data was entered within 60 days while 73% of the data was entered within 90 days of the injury. On a per-facility basis, data entry within 60 days ranged between 5% and 92% while that within 90 days ranged between 11% and 97%. Table 2.5 depicts the overall timeliness of the data on a per-facility basis while Figure 2.4 presents the proportion of data entered within 90 days.

Facility	**Total sample (N)**	**% data entered within 60 days**	**% data entered within 90 days**
A	231	89.6% (207)	96.9% (224)
B	88	4.6% (04)	11.37% (10)
C	142	71.8% (102)	71.8% (102)
D	33	54.5% (18)	66.6% (22)
E	200	92.5% (185)	92.5% (185)
F	186	49.4% (92)	55.91% (104)
G	11	90.9% (10)	90.9% (10)
Total	891	69.3% (618)	73.7% (657)

Table 2.5 Data Timeliness

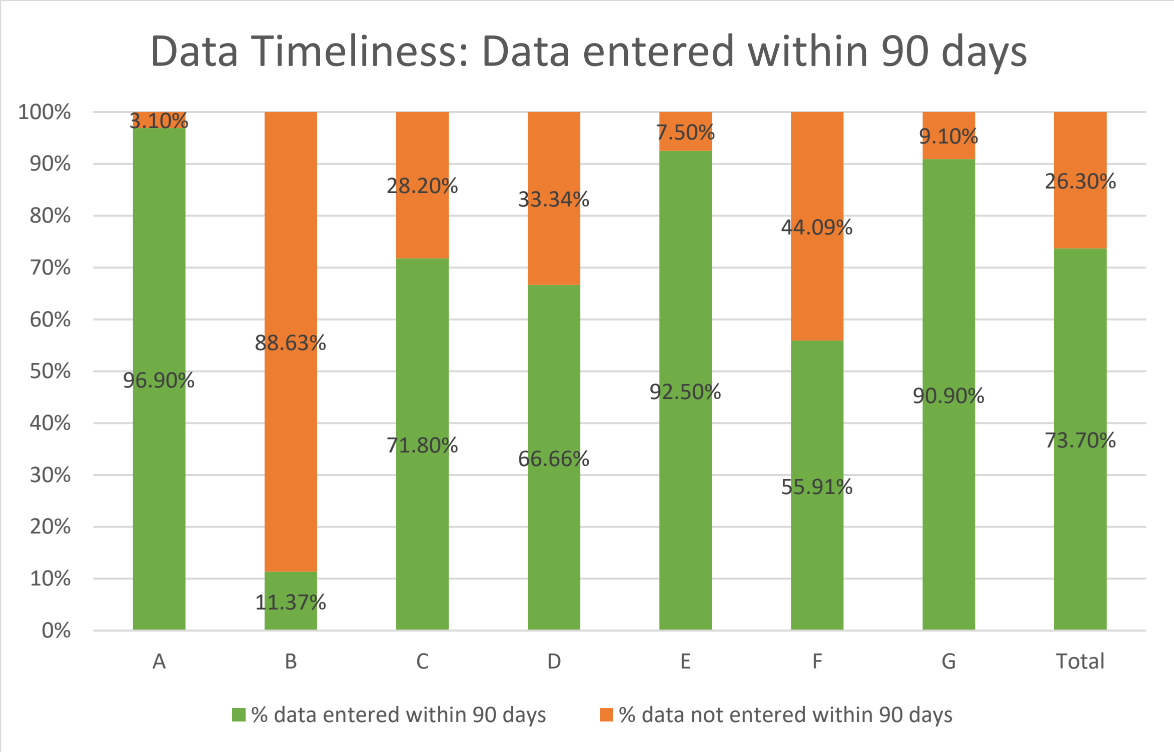


Figure 2.4 Data Timeliness

Overall, the minimum time to complete the data entry (to be considered "closed") was within the same day of entry; while the maximum time to close was about 4.5 years. The maximum time to close among the different facilities ranged from 10 months to 4.5 years. Table 2.6 summarizes the per-facility minimum and maximum time to close.

Facility	**Minimum time to close**	**Maximum time to close**
A	Within the same day	10 months 11 days
B	Within the same day	4 years 5 months 2 days
C	Within the same day	4 years 6 months
D	Within the same day	1 year 1 month 11 days
E	Within the same day	4 years 1 month 5 days
F	Within the same day	1 year 9 month 15 days
G	Within the same day	1 year 6 months 4 days
Overall	Within the same day	4 years 5 months 2 days

Table 2.6 Data Timeliness from minimum time to close to maximum time to close

2.4.7 Coverage

An additional domain of *Coverage* was added to the Wang and Strong domains to ensure that the registry captures all injuries of interest to the trauma system using practices of the NTDB (Coverage). For coverage, currently the data registry is comprised of data from the seven facilities in Abu Dhabi and does not cover all facilities in the emirate, much less the facilities in the country. Comprehensive coverage will eventually be achieved once the registry expands to other health care facilities in Abu Dhabi.

2.5 DISCUSSION

2.5.1 Summary of Study Findings

Starting from a total of 20,562 cases, after excluding 2,735 cases, a random sample of 5% was selected from the remaining 17,827 cases and the data quality was assessed on a sample of 891 cases. To summarize:

For *Completeness*, data was 100% complete for variables including age and gender. Among all the 14 variables, *Completeness* ranged between 99.8% for Hospital Discharge Disposition and 54% for TRISS. Overall data *Accuracy* ranged between 90.6% and 99.16%. Overall *Concordance* ranged from 95% to almost 100%. For *Correctness*, the imputation process is automated and consistent with the edit rules and the built-in processes in the registry based on ACS standards. For *Consistency*, all data elements were consistent within the data dictionary and conformed to data dictionary standards. For *Timeliness*, about 70% of the overall data was entered within 60 days while 73% of the data was entered within 90 days of the injury which was reasonably acceptable. On a per-facility basis, data entry within 60 days ranged between 5% and 92% while data entry within 90 days ranged between 11% and 97%. Overall, the minimum time to close was within the same day of entry while the maximum time to close was about 4.5 years. For *Coverage*, the data registry is currently comprised of data from seven facilities in Abu Dhabi; 100% coverage will eventually be achieved once the registry expands to other health care facilities in Abu Dhabi.

2.5.2 Comparison with the data from the literature

There is very limited existing data from the region on the data quality of trauma registries for comparison. Existing evidence suggests that data quality assessments in trauma registries have been limited to a few aspects of data quality and that there is a lack of standardized methods to evaluate the data quality for trauma registries [13, 14, 16, 17]. In contrast to these findings, our study adopted the Wang and Strong [18] landmark conceptual model for measuring the data quality that assesses the data over a broad range of six dimensions: *Completeness* (all necessary data are provided), *Accuracy* (data match a verifiable source), *Precision* (data values are specific), *Correctness* (data are within specific value domains), *Consistency* (data are logical throughout data points), and *Timeliness* (the availability of the trauma registry when required). We also added an additional dimension of *Coverage* to our study.

2.5.3 Study Strengths and Limitations

Our study describes the most recent and, to our knowledge, the first ever regional analysis of data quality of the trauma registry in Abu Dhabi. The results from our study can serve as the baseline to enable organizers and policy makers to learn more about the magnitude of trauma in Abu Dhabi and lead to a better understanding of the strengths and weaknesses of the current practices. A major strength of this project is the ability to examine the quality of this registry using a scientific methodology. Another strength is the comprehensiveness of this registry, which has over 20,000 cases with over 300 variables per case. This gives us the ability to look at the system from several angles. We can utilize all findings to improve the current system and share the experience with the scientific community.

A major limitation in the project is that the registry data used are from seven out of the nine facilities in the Emirate of Abu Dhabi, which limits the “coverage” of the registry and the generalizability of the data. However, based on impressions gathered from local trauma clinicians, it is believed that these facilities see the majority of major trauma in the Emirate, either by being the first receiving facility or by receiving a referral from another hospital. Another limitation is the type of data used for the study, which do not have rigorous quality assurance processes in place at the facility level. Very few facilities within the system have the full-time staff necessary to enter the data, which may have affected several of the aforementioned quality domains and therefore, the validity of the results of this analysis. One last limitation is the study timeline. Data quality studies may require more time compared to the timeframe we have available, which was from 2014 to 2017, which in turn limited the size of the data available for analysis.

2.5.4 Policy Implications

Although these findings are based on the trauma registry of seven facilities in Abu Dhabi and the data spans the period from 2014 to 2017, the study still has major policy implications. The seven facilities included here are the major trauma facilities in the Emirate and this study provides a baseline assessment for improving the data quality and existing coverage of the trauma registry in the region. Several policies can be implemented, including mandating the trauma reporting of all facilities in Abu Dhabi with the funding for full-time staffing to ensure a robust trauma registry and benchmarking the data internationally, to mention just two.

2.6 CONCLUSION

To our knowledge, this paper is the very first analysis of the data quality of a trauma registry in Abu Dhabi that summarizes the data quality across seven domains. The results of our study provide reassurance regarding the good quality of the data thus far; which can provide a foundation for the further improvement in data quality and coverage in the region.

2.7 REFERENCES

1. *WHO, Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018. 2018.*

2. *Haagsma, J.A., et al., The global burden of injury: incidence, mortality, disability-adjusted life years and time trends from the Global Burden of Disease study 2013. Injury prevention, 2016. 22(1): p. 3-18.*

3. *Roth, G.A., et al., Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet, 2018. 392(10159): p. 1736-1788.*

4. *Stelfox, H.T., et al., Quality indicators for evaluating trauma care: a scoping review. Archives of Surgery, 2010. 145(3): p. 286-295.*

5. *Jurkovich, G.J. and C. Mock, Systematic review of trauma system effectiveness based on registry comparisons. Journal of Trauma and Acute Care Surgery, 1999. 47(3): p. S46-S55.*

6. *MacKenzie, E.J., et al., The national study on costs and outcomes of trauma. Journal of Trauma and Acute Care Surgery, 2007. 63(6): p. S54-S67.*

7. *Organization, W.H., Eastern Mediterranean status report on road safety: call for action. 2010.*

8. *Al-Thani, H., et al., Workplace-related traumatic injuries: insights from a rapidly developing Middle Eastern country. Journal of environmental and public health, 2014. 2014.*

9. *Asim, M., et al., Blunt traumatic injury in the Arab Middle Eastern populations. Journal of emergencies, trauma, and shock, 2014. 7(2): p. 88.*

10. *Nwomeh, B.C., et al., History and development of trauma registry: lessons from developed to developing countries. World journal of emergency surgery, 2006. 1(1): p. 32.*

11. *Moore, L. and D.E. Clark, The value of trauma registries. Injury, 2008. 39(6): p. 686-695.*

12. *Zehtabchi, S., et al., Trauma registries: history, logistics, limitations, and contributions to emergency medicine research. Academic Emergency Medicine, 2011. 18(6): p. 637-643.*

13. *O'Reilly, G.M., et al., Trauma registries in developing countries: a review of the published experience. Injury, 2013. 44(6): p. 713-721.*

14. *Pronovost, P.J., M. Miller, and R.M. Wachter, The GAAP in quality measurement and reporting. JAMA, 2007. 298(15): p. 1800-1802.*

15. *Hlaing, T., L. Hollister, and M. Aaland, Trauma registry data validation: essential for quality trauma care. Journal of Trauma and Acute Care Surgery, 2006. 61(6): p. 1400-1407.*

16. *Shivasabesan, G., B. Mitra, and G.M. O'Reilly, Missing data in trauma registries: A systematic review. Injury, 2018. 49(9): p. 1641-1647.*

17. *Porgo, T.V., L. Moore, and P.-A. Tardif, Evidence of data quality in trauma registries: a systematic review. Journal of trauma and acute care surgery, 2016. 80(4): p. 648-658.*

18. *Strong, D.M., Y.W. Lee, and Y.-Y.R. Wang, Beyond accuracy: how organizations are redefining data quality. 1994: Total Data Quality Management Research Program, Sloan School of Management ....*

CHAPTER 3: EPIDEMIOLOGY OF TRAUMA IN ABU DHABI: FIRST ANALYSIS OF THE ABU DHABI TRAUMA REGISTRY

3.1 ABSTRACT

3.1.1 Background

Trauma, including road traffic injuries, has become a major public health concern. Between 2007 and 2017, the total deaths from trauma increased by 2.3% globally. Currently, accurate data about the epidemiology of trauma in the region is lacking.

3.1.2 Methods

This was a retrospective observational study based on data from the Abu Dhabi Trauma registry. Data on trauma cases presenting to seven facilities in Abu Dhabi between 2014 and 2017 were extracted from the registry. Statistical analysis was performed using STATA/IC version 16. Regression was performed to assess the impact of age, gender, mechanism of trauma, and ISS score on mortality and length of hospital stay.

3.1.3 Results

A total of 20,562 trauma cases were identified from the trauma registry data and final analysis was performed on a sample of 17,827 cases. The majority of patients were male, aged 21 to 50 years old. The two major mechanisms of injuries (over 70%) were road traffic injuries (39%) and falls (34%). Public roads and homes were the most common places of injury. About 17% of the injuries were work-related injuries, where the mechanism of injury for more than half of the work-related injuries was a fall. Out of the total trauma admissions, over 60% of the cases were ISS category < 9; about 25% cases were ISS categories 9 to 15; about 8% of the cases were ISS categories 16 to 24; and 5% of the cases were admitted with ISS category 25 and above.

Overall, the mean length of hospital stay was 6.49 days, ranging between 3.68 days for blunt injuries and 10.05 days for burn injuries. The overall mortality in our sample was 1.41%, with the highest case fatality caused by road traffic injuries (57%), followed by falls (21%). Regression analysis suggests a statistically significant increase in the length of a patient's hospital stay with increasing age and increasing ISS score. There was a significant increase in mortality with age when older groups were compared to a reference group under age 19: age 19–65 years (OR: 2.77, 95% CI: 1.81 to 4.23); > 65 years (OR: 1.39, 95% CI: 1.39 to 5.73). A similar increase was seen with the ISS score when patients with higher severity were compared to a reference group of patients with scores < 9: score 9–15 (OR: 5.5, 95% CI: 3.14 to 9.63); score 16–24 (OR: 21.32, 95% CI: 12.35 to 36.82); and score > 25 (OR: 114.3, 95% CI: 69.51 to 187.94). There was no difference in the length of hospital stay or mortality rates by gender.

3.1.4 Conclusion

Our paper presents the first analysis of the trauma registry in Abu Dhabi. Such data will facilitate the planning and the implementation of policies related to trauma prevention in the Emirate of Abu Dhabi.

3.2 INTRODUCTION

3.2.1 Introduction

Trauma, including road traffic injuries (RTI), has become a major public health concern. Approximately 4.9 million deaths were attributable to trauma in 2016; more than a quarter of these deaths were due to road traffic injuries [1]. According to the most recent Global Burden of Diseases (GBD), Injuries, and Risk Factors study, approximately 520 million people sustained trauma that warranted some type of healthcare in 2019 [2]. Globally, the total deaths from trauma increased by 2.3% between 2007 and 2017, while the overall death rate decreased by 13.7% to 57.9 deaths per 100,000 in 2017 [3].

3.2.2 Trauma Burden in the UAE

Globally, there has been a profound change in the health landscape with an increase in the burden of Non-Communicable Diseases (NCDs) compared to the communicable diseases. The health epidemiology of the United Arab Emirates (UAE) has also transitioned over time [4]. In the Middle East, traumatic injuries cause a major burden on the healthcare system. As countries in the Middle East and North Africa (MENA) region have become more developed, with improved motorization rates and road infrastructure networks, trauma related to road traffic injuries, construction, and petrochemical industries has risen.

Road traffic injuries have also been reported to increase over time at an alarming rate. Countries like Libya (40.5), Iraq (38.1), the United Arab Emirates (37.1), and Jordan (34.2) bear the highest estimated road traffic death rate per 100,000 people in the Middle East [5, 6]. According to the GBD 2019 data, road injuries remain the leading cause of the disability-adjusted life years (DALYs) among 10 to 24 and 25 to 49 years age group contributing to about 6.6% and 5.1% of total DALYs respectively in these two age groups [4, 7].

In the UAE, the incidence of occupational injury was reported as 136/100,000 workers per year [8]; the main causes of such injuries were falls from a height (51%) and being struck by a heavy object (15%) [9], However there are wide regional differences within the Middle East in terms of economic and other conditions, and consequently a regional situation analysis is required [10].

More recently, the death rates from trauma have decreased due to improved access to healthcare services, which has led to increased DALYs. Owing to the increasing morbidity, individuals and society incur a substantial financial burden as a result of the increased rehabilitation needs and loss of productivity. The health care systems of several middle-income countries in the Gulf region are overburdened with traffic-related injuries among pedestrians, passengers of motor vehicles, and cyclists [6, 11, 12].

3.2.3 Scarcity of Trauma Data in the UAE

The United Nations, through its Sustainable Development Goals (SDGs) program, aimed to reduce the number of deaths and injuries from road traffic injuries by half by 2020 [13]. In order to achieve this type of goal, there is a need to assess the existing burden of morbidities leading to premature deaths. However, there is a scarcity of data assessing the patterns of trauma in the Middle East [6, 9]. This can be attributed to a lack of appropriate recording and analysis of trauma data and inconsistencies in the existing documentation. This situation is further complicated by the fact that the existing data collection efforts are prone to negligence and underreporting [5, 6]. Therefore, a region-specific study assessing the epidemiology and burden of injuries and trauma would help all of us understand the distribution in the region and strengthen surveillance in order to implement policies related to trauma prevention.

3.2.4 Importance of the Trauma Registry

Trauma registries are databases that collect information regarding acute care delivered to patients hospitalised with trauma. The major objective of this repository of information is to assess and improve the efficiency and quality of trauma care at the trauma units or facilities [14]. They are commonly used for quality improvement projects for trauma care within hospitals and/or in trauma systems as a whole. Such data may also be used for additional purposes like designation and accreditation processes. The data captured from the registry help in benchmarking different local and international data; furthermore, it can help in comparing hospital-to-hospital performance. Another use of trauma registries is for the evaluation of clinical intervention(s).

The data from trauma registries also help in generating hypotheses, planning for protocols, and also recruiting candidates for trials. The large size of the registries helps in identifying rare injuries. An important benefit of the trauma registries is their help to medical professionals in shaping prevention strategies. Although often not fully utilized, the data generated from trauma registries can help in planning for community-specific and data-driven injury prevention campaigns. However, trauma registries have certain drawbacks. Trauma registries in some facilities might not represent true population level characteristics due to differences in case inclusion and exclusion criteria, varying data content, and limited geographic and population coverage [15]. Moreover, concerns regarding the completeness and quality might also limit the utility of trauma registries [14, 15].

For this study, we utilised the data from the existing trauma registry of seven facilities in Abu Dhabi collected between 2014 and 2017. This data registry is the first of its kind in the region and collects data on trauma patients from multiple facilities in Abu Dhabi. The Trauma Registry is hosted by the Department of Health (DOH) and the major components of the registry follow the American College of Surgeons' Committee on Trauma (ACS-COT) as well as its National Trauma Data Standard (NTDS) and the National Trauma Data Bank (NTDB). The registry is managed by a manager responsible for meeting with the participating hospitals in order to discuss the registry-related issues on a monthly basis.

3.3 METHODS

3.3.1 Goals and Objectives

We conducted a multi-centre, retrospective observational study to assess the epidemiology and burden of trauma in Abu Dhabi. The specific objectives of this study are as follows:

1. To describe the trends and demographics of trauma over four years from seven facilities in Abu Dhabi.
2. To assess the characteristics and mechanisms of all trauma as well as work-related trauma.
3. To assess the factors associated with the length of stay among patients with trauma.
4. To assess the factors associated with mortality among patients with trauma.

3.3.2 Study Design

This was a retrospective observational study based on the data from a group trauma registry with contributions from seven emergency department units of Abu Dhabi.

3.3.3 Study Settings

Data on trauma cases presenting to seven facilities in Abu Dhabi between 2014 and 2017 were extracted from the registry. Inclusion criteria were all trauma cases, as per the trauma registry inclusion criteria, which were as follows:

- Includes at least one code within the range of the following injury diagnostic codes, as defined in the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM): 800–959.9
- Excludes all diagnostic codes within the following code ranges:
    - 905–909.0 (late effects of injuries)

- 910–924.9 (superficial injuries, including blisters, contusions, abrasions, insect bites)
- 930–939.9 (foreign bodies)

- And must also include one of the following criteria: Hospital admission; patient transfer via emergency medical service transport (including air ambulance from one hospital to other hospital); or death resulting from traumatic injury (independent of hospital admission or hospital transfer status).

The total number of beds in these facilities was 2,551; ranging from less than 200 beds to over 600 beds. The facilities are a combination of public, private, and military facilities. Geographically, two facilities were from Abu-Dhabi Island; two were from the Abu Dhabi Region; one was from the Eastern Region; and two were from the Al Dhafra Region (Figure 3.1).

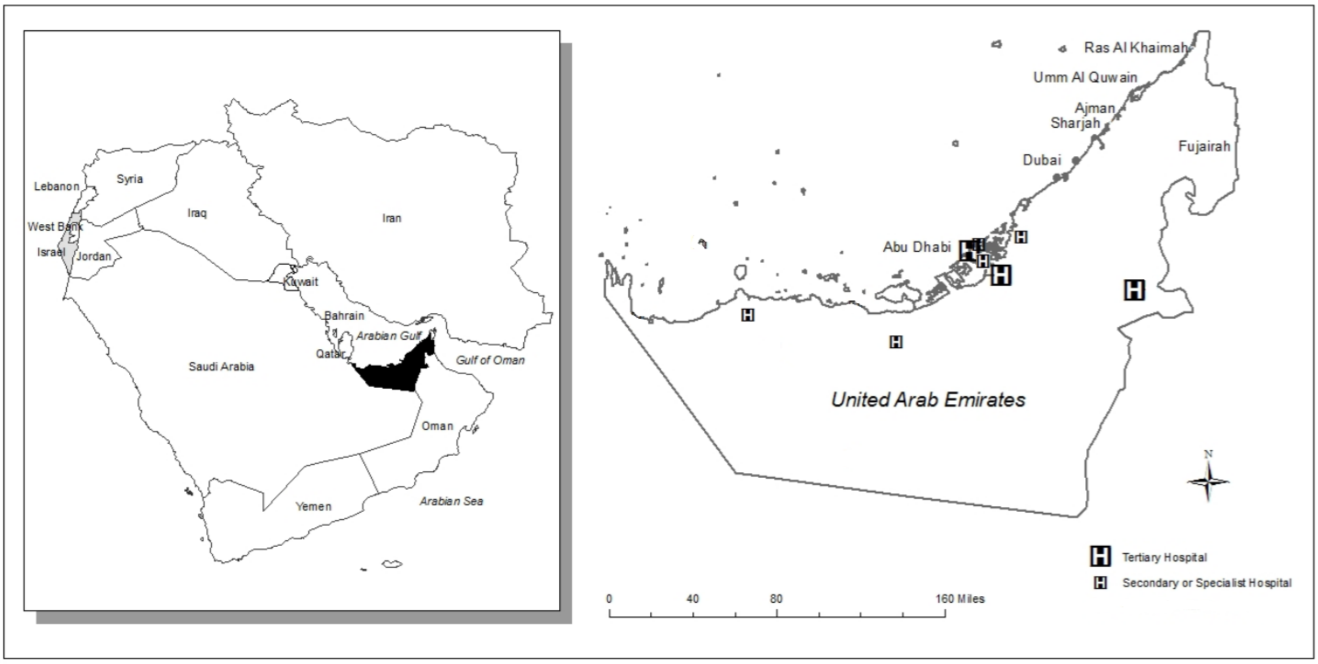


Figure 3.1 Participating Hospitals in Abu Dhabi

For details on the facilities, see Table 3.1.

Facility Characteristic	Number (%)
No. of hospitals submitted data	7
No. of facilities by bed size:	
< 200	1 (14.2%)
201–400	2 (28.5%)
401–600	3 (42.8%)
> 600	1 (14.2%)
Total number of beds	2551
Types of facilities	
Public facilities	5 (71.4%)
Private facilities	1 (14.2%)
Military facility	1 (14.2%)
Facilities by region:	
Abu-Dhabi Island	2 (28.5%)
Abu-Dhabi Region	2 (28.5%)
Eastern Region	1 (14.5%)
Al-Dhafra Region	2 (28.5%)

Table 3.1 Facility Information

3.3.4 Data Gathering

The following data were extracted for each case: demographics (age, gender, ethnicity, and mode of transportation for getting to the hospital); emergency visit information (time, day, month, and facility); injury characteristics (type of injury, mechanism of injury, place of injury, and work- or non-work-related injury); Injury Severity Score (ISS); patient disposition (discharged, intensive care unit days, ventilator days, and step days); length of stay; and mortality (defined as “dead” at the time of discharge).

3.3.4 Statistical Analysis

Statistical analysis was performed using STATA/IC version 16 [16]. Dichotomous data are presented as frequencies and percentages while continuous data are presented as means and standard deviations (SD). Regression was performed to assess the impact of age, gender, mechanism of injury, and ISS score on mortality and length of stay. Statistical significance was set at $p < 0.05$. Univariate analysis was performed with the Mann-Whitney U test, bivariate analysis with the chi-square test, and multivariate logistic regression was performed using binomial regression [17]. We have reported the findings for regression analyses as odds ratios (OR) with 95% confidence intervals (CI) for mortality and linear coefficients with 95% CI for length of hospital stay.

3.3.5 Institutional Review Board (IRB) Approval

Institutional Review Board (IRB) Approval for the study was obtained from the Zayed Military Hospital, Abu Dhabi.

3.4 RESULTS

These results summarise data from the Abu Dhabi Trauma Registry describing regional demographic patterns of trauma, outcomes, and predictors of length of hospital stay and mortality among trauma patients in Abu Dhabi. A total of 20,562 trauma cases were identified from the trauma registries; data were excluded for 2,664 cases where the data was from those facilities which were unable to participate in the study. Data for 71 cases were excluded (50 files were incomplete despite the cases being closed while 21 files were still labelled as "active files" since the files were not closed). Final analysis was performed on a sample of 17,827 cases (Figure 3.2). Distribution of patients according to the year and facility are presented in Figure 3.3.

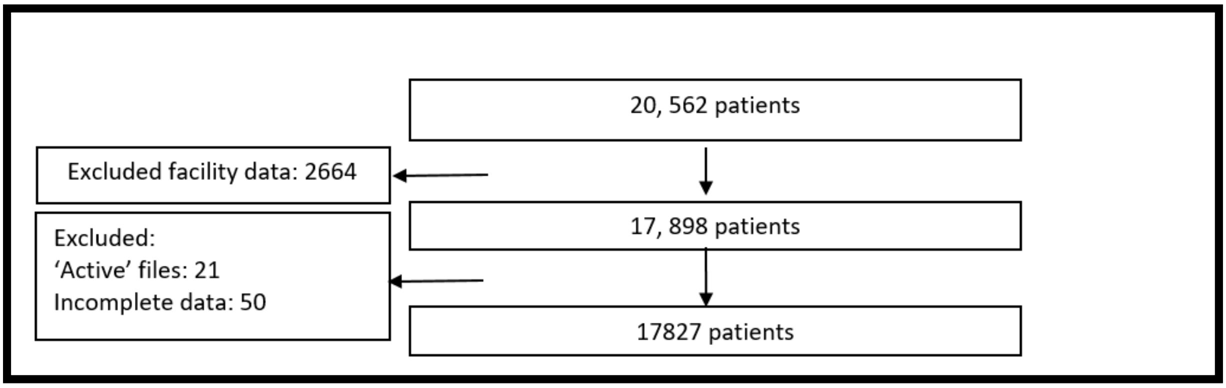


Figure 3.2 Study Flow of Participants

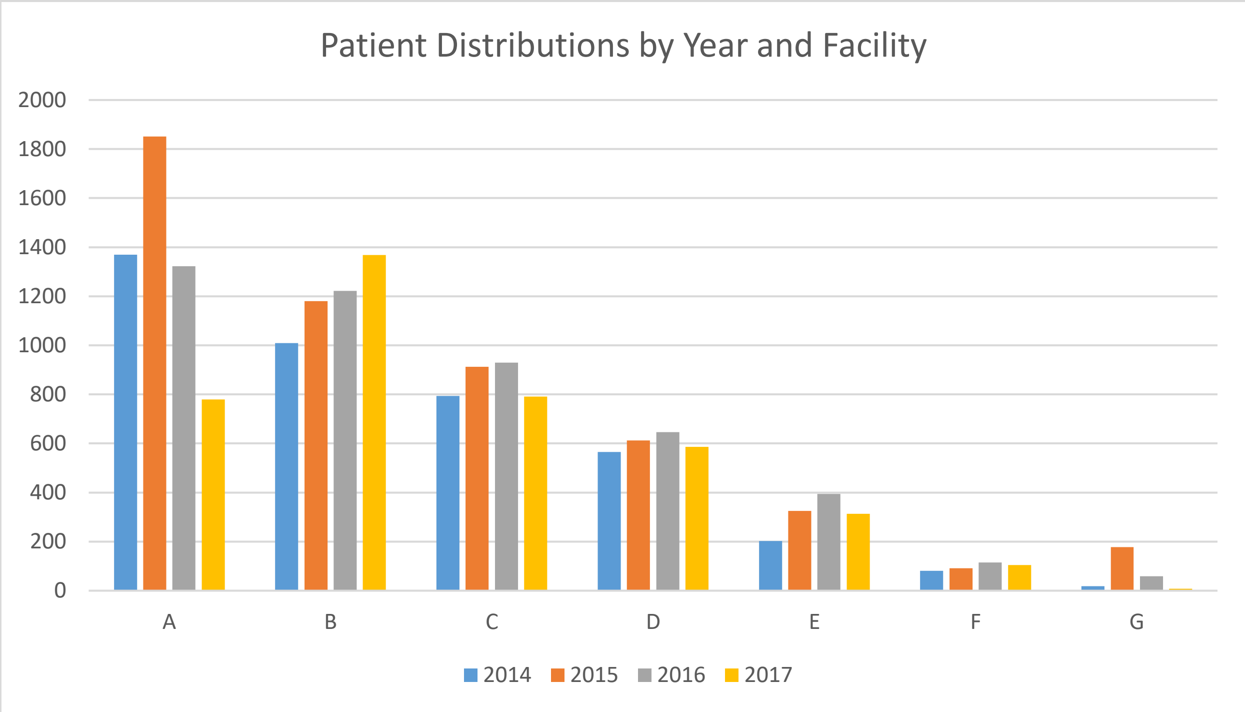


Figure 3.3 Patient Distributions by Year and Facility

3.4.1 Frequencies of Major Variables from the Trauma Registry

The demographic characteristics of the participants are displayed in Table 3.2. The majority of the patients (about 80%) were male. Almost half of the patients (49.9%) were aged 21 to 40 years old. The gender and age distributions of the study population compared to the overall population of Abu Dhabi are depicted in Figure 3.4. The population distribution in the study is representative of the population distribution of the overall Abu Dhabi population (per data available from 2011). The gender distribution of the patients indicates that there were more male patients compared to female patients in the 0 to 14 years age group; 15 to 50 years age group; and in the above 50 years age group. Among female patients, the proportion of females aged 0–14 years was 27.86%; the proportion of females aged 15 to 50 was 49.77%; while the proportion of females aged over 50 years was 22.36%. Among the male counterparts, the proportion of 0–14 years age group was 15%; proportion of 15 to 50 years was 74%; while the proportion above 50 years was 10.73%.

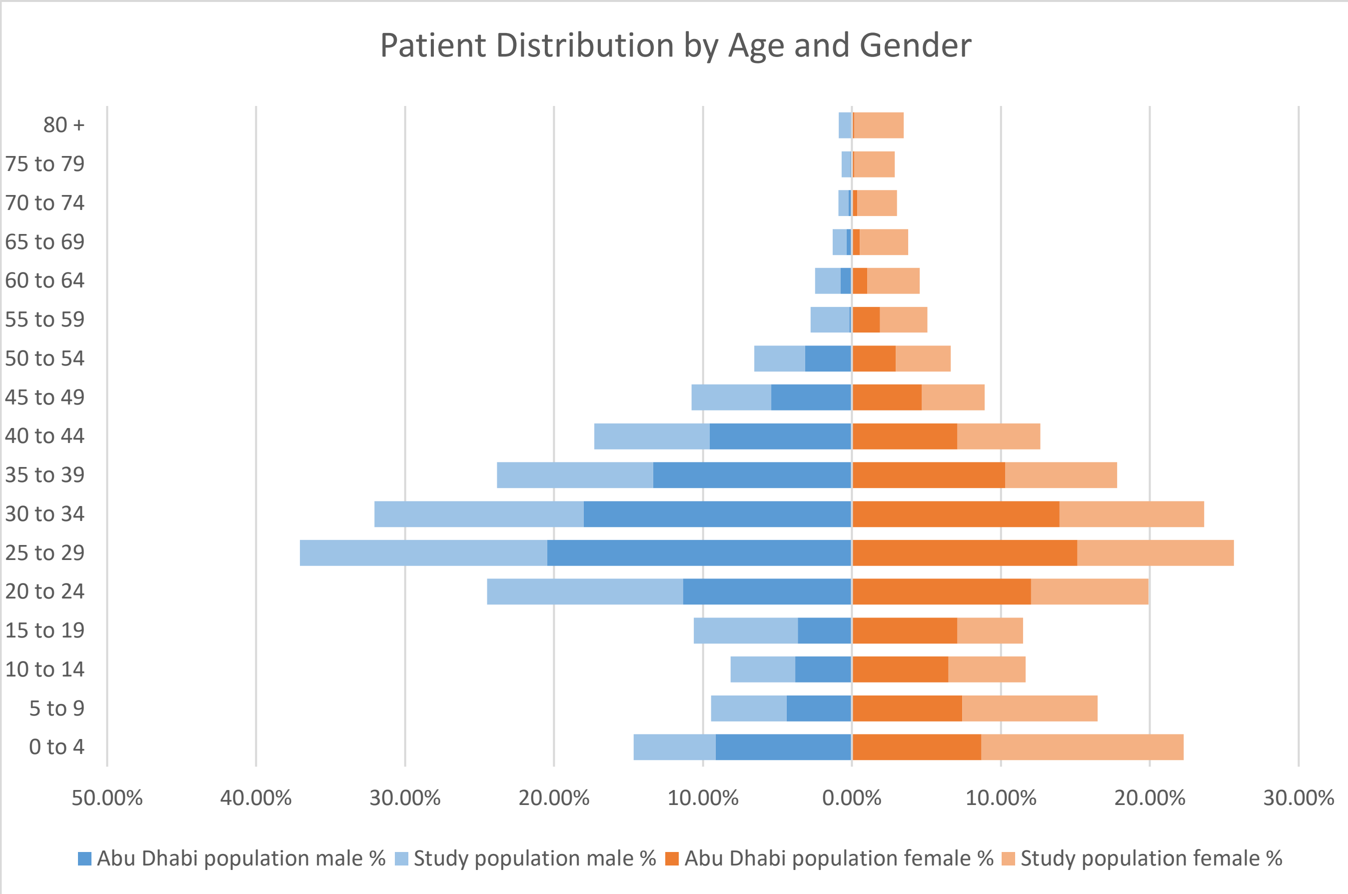


Figure 3.4 Study Patient Distribution Compared to Abu Dhabi Population Distribution by Age and Gender

Characteristics	***Number (%)*** ***N=17827***
Total patients	
2014	4,039 (22.65%)
2015	5,151 (28.89%)
2016	4,687 (26.29%)
2017	3,950(22.15%)
Missing	0%

Patients by facility	
A	5,321 (29.84%)
B	4,779 (26.80%)
C	3,427 (19.22%)
D	2,411 (13.52)
E	1,234 (6.92%)
F	392 (2.19%)
G	263 (1.47%)
Gender	
Male	14,282 (80.11%)
Female	3,542 (19.86%)
Missing	3 (0.01%)
Age distribution	
< 2years	364 (2.2%)
2–10 years	1,882 (11.7%)
11–20 years	1,953 (12.1%)
21–30 years	4,510 (28.1%)
31–40 years	3,502 (21.8%)
41–50 years	1,820 (11.3%)
51–60 years	966 (6%)
61–70 years	514 (3.2%)
>70 years	500 (3.1%)
Missing	2 (0.01%)
Mode of transportation	
Ground ambulance	2,378 (13.33%)
Helicopter ambulance	14 (0.07%)
Police	28 (0.14%)
Private vehicle/Walk-in	2,364 (13.26%)
Missing/Not applicable	13,043 (73.16%)

Patient nationality	
UAE national	5,893 (32.7%)
Other nationals	11,036 (62.3%)
Missing	898 (5.03%)
Place of Injury	
Public Roads	6,758 (37.90%)
Home	5,575 (31.27%)
Worksite	2,841 (15.93%)
Desert/Sea	559 (3.13%)
Other Public Places	495 (2.77%)
Sports Facility	294 (1.64%)
School	216 (1.21%)
Farm	186 (1.04%)
Residential Institutions	78 (0.43%)
Others	312 (1.75%)
Missing	518 (2.90%)
Work-related injuries (*)	3,066 (17.19%)
Missing	317 (1.77%)
Alcohol intoxication (**)	66 (1%)
Missing	11,080 (62.15%)
Length of hospital stay (days)	Median: 3 days; Mean: 6.49
0–3 days	10,372 (58.18%)
4–7 days	3,786 (21.23%)
8–15 days	2,132 (11.95%)
16–30 days	866 (4.85%)
> 30 days	582 (3.26%)
Missing	89 (0.49%)
ISS score	Median: 4; Mean: 7.4
ISS Category	

< 9	10,971 (62.44%)
9–15	4,351 (24.76%)
16–24	1,388 (7.89%)
> 24	860 (4.89%)
Missing	257 (1.44%)
Injury pattern	
Head	3,993 (22.39%)
Face	2,884 (16.17%)
Neck	578 (3.24%)
Thorax	3,139 (17.60%)
Abdomen	1,750 (9.81%)
Spine	2,788 (15.63%)
Upper extremity	6,046 (33.91%)
Lower extremity	5,987 (33.58%)
ICU days (mean)	2.52 days
Ventilator days (mean)	1.69 days
Step down days (mean)	4.96 days
Blood or blood products requirement according to ISS categories	
Total	644
< 9	82 (12.73%)
9–15	256 (37.75%)
16–24	147 (22.82%)
> 24	159 (24.68%)

Table 3.2 Frequencies of Major Variables from the Trauma Registry

* Indication of whether the injury occurred during paid employment.

** Use of alcohol by patient as assessed by blood alcohol concentration (BAC).

Information about the mode of transportation to the hospital was available for only a quarter of patients; these data were missing for over 70% of the patient entries. Ground ambulance and private vehicle/walk-ins were the most common modes of transportation. Over 60% of the patients were other than UAE nationals. Public roads and homes were the most common places of injury. About 17% of the injuries were work-related injuries while the mechanism of injury for about 42% of the work-related injuries was a fall (Figure 3.5). The majority of trauma patients had an ISS score below 9 (62%); about a quarter of the patients were admitted with an ISS score of 9 to 15; about 8% of the patients had an ISS score of 16 to 24; and 5% of the patients were admitted with as ISS score of over 25. In terms of the injury pattern, the majority of the injuries were related to upper (33%) and lower (33%) extremities, followed by head (22%), and thorax (17%).

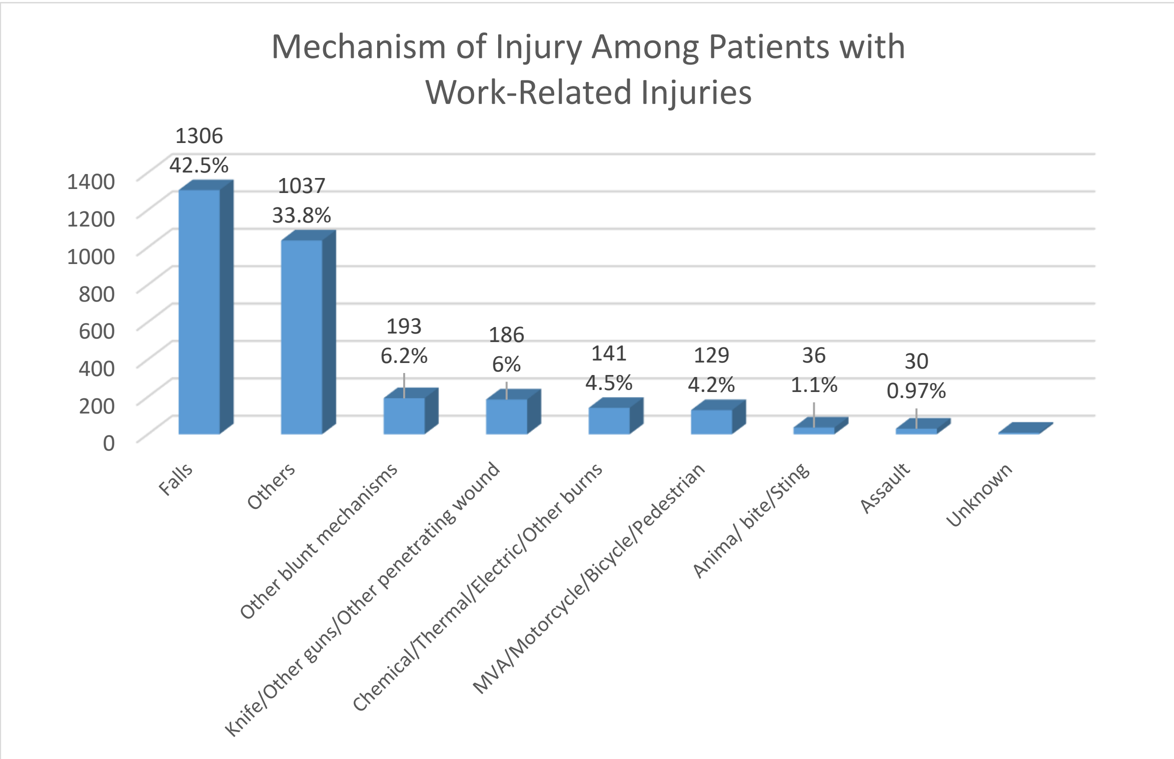


Figure 3.5 Mechanism of Injury among Patients with Work-Related Injuries

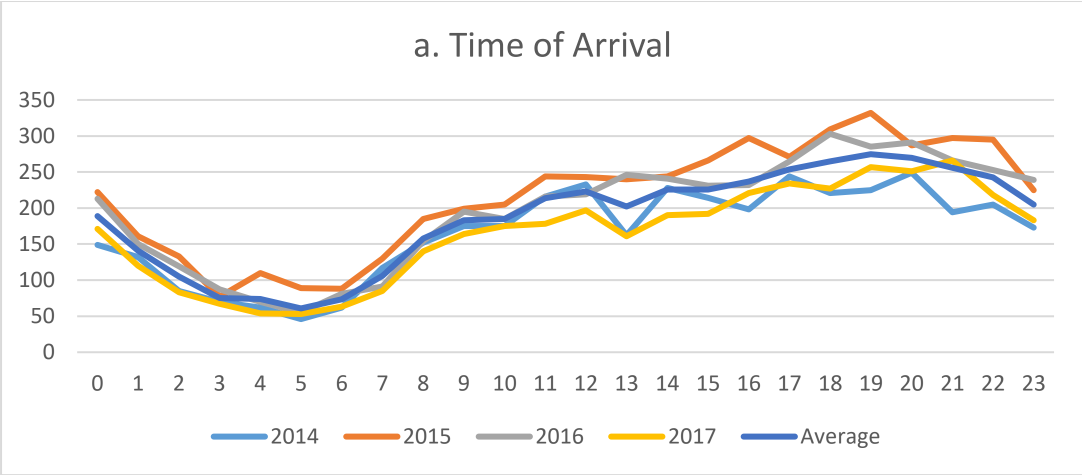
3.4.2 Trauma Characteristics

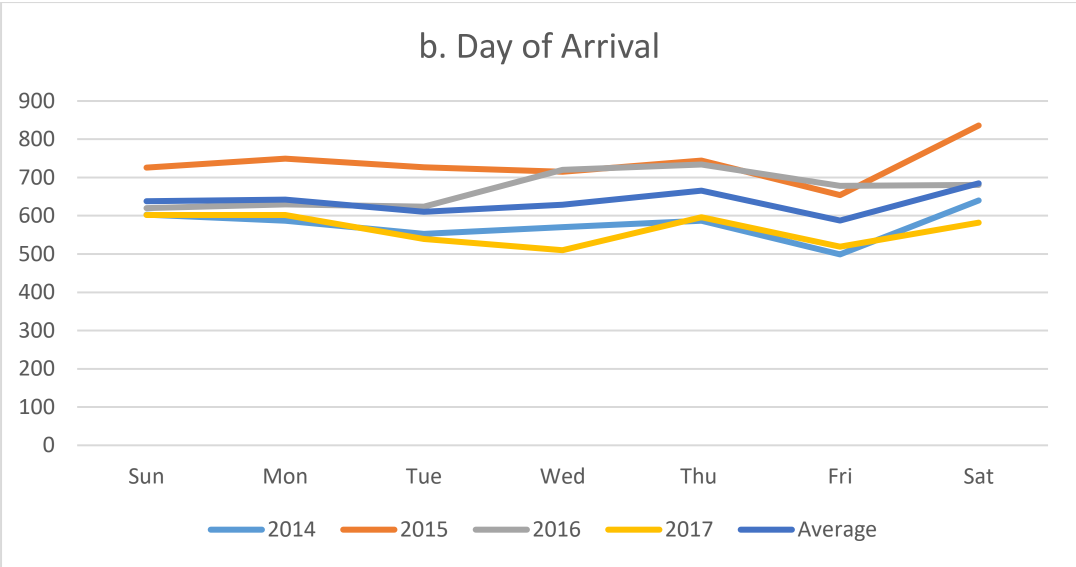
Approximately 6% of the total admissions to all the facilities were trauma admissions (Table 3.3). The rate of trauma admission according to the facility ranged between 15 per 1,000 to 76 per 1,000 patients. The annual rate of admission for 2014 was 51 per 1,000; for 2015 it was 68 per 1,000; for 2016 it was 62 per 1,000; while for 2016 it was 53 per 1,000.

Hospitals	2014			2015			2016			2017			Total		
	Total admission	Trauma admission	Rate per 1000	Total admission	Trauma admission	Rate per 1000	Total admission	Trauma admission	Rate per 1000	Total admission	Trauma admission	Rate per 1000	Total admission	Trauma admission	Rate per 1000
A	19,207	1,009	52.5	1,8025	1,180	65.4	18,112	1,222	67.4	18,876	1,368	72.4	74,220	4,779	64.3
B	6,078	202	33.2	5,872	325	55.3	6,145	394	64.1	6,253	313	50.0	2,4348	1,234	50.6
C	9,219	566	61.3	8,988	613	68.2	8,672	646	74.4	8,113	586	72.2	34,992	2,411	68.9
D	2,145	18	8.3	2,036	178	87.4	2,005	59	29.4	1,986	8	4.0	8,172	263	32.1
E	18,581	1,369	73.6	16,360	1,851	113	17,136	1,322	77.1	17,250	779	45.1	69,327	5,321	76.7
F	16,506	794	48.1	16,461	913	55.4	16,237	929	57.2	16,469	791	48.0	65,673	3,427	52.1
G	6,933	81	11.6	6,917	91	13.1	6,090	115	18.8	4,891	105	21.4	24,831	392	15.7
Totals	78,669	4,039	51.3	74,659	5,151	68.9	74,397	4,687	62.9	73,838	3,950	53.5	301,563	17,827	59.1

Table 3.3 Rate of Trauma Admissions

Figure 3.6 depicts the annual influx of patients according to the time of the day, day of the week, and month of the year. The maximum influx of patients was between 1200 hours and midnight while the influx remained lowest between 0300 and 0600. According to the days of the week, the maximum numbers of patients were seen on a Saturday while minimum number of patients were seen on a Friday. In terms of months, the lowest numbers were seen in the summer months between June and August while the patient flow was comparatively higher in the winter months between November and February.


a. Time of Arrival
350
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
2014
2015
2016
2017
Average


b. Day of Arrival
900
800
700
600
500
400
300
200
100
0
Sun Mon Tue Wed Thu Fri Sat
2014
2015
2016
2017
Average

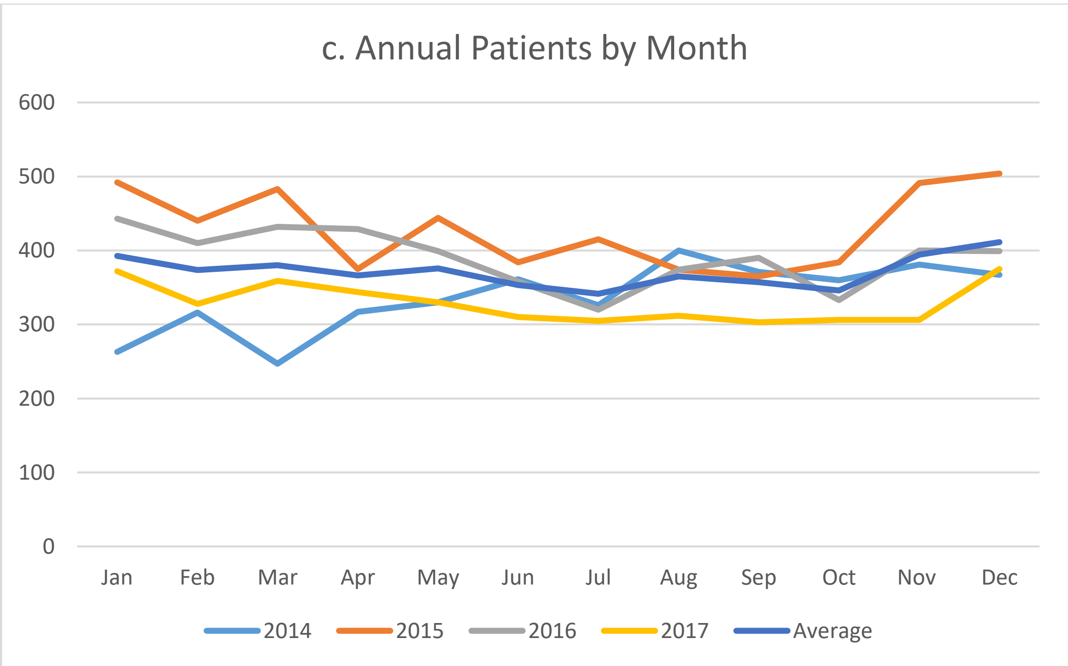

c. Annual Patients by Month
600
500
400
300
200
100
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2014
2015
2016
2017
Average

Figure 3.6 Patient Influx (a. Hour of Arrival; b. Day of Arrival; c. Month of Arrival)

Over 70% of the patients were admitted with the two major mechanisms of injuries: road traffic injuries (39%) and falls (34%) (Figure 3.7). These were followed by burns (5%), knives and other penetrating wounds (4%), other blunt mechanism injuries (4%), and assault/biting (3%).

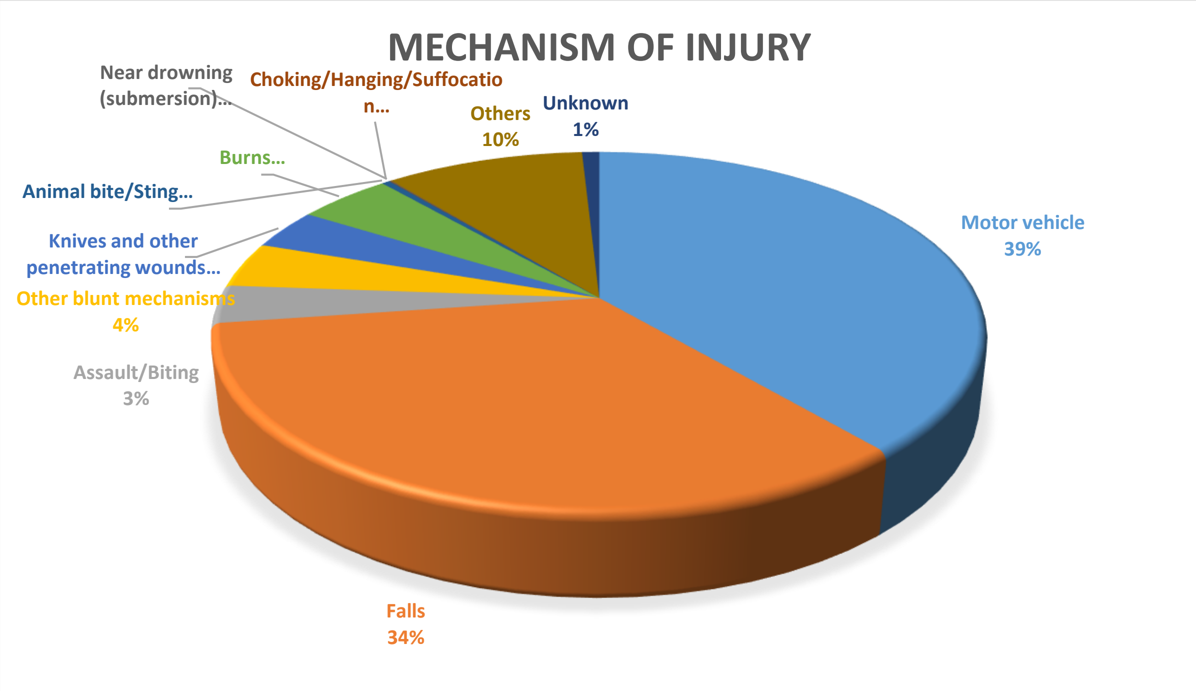


Figure 3.7 Mechanism of Injury

Table 3.4 depicts the annual distribution of the mechanism of injury. The top two causes of injuries, including road traffic injuries and falls, have remained consistently high from 2014 to 2017. Burn injuries (including chemical, inhalation, thermal, electric burns, and other burns) showed a decreasing trend from 2014 to 2017 with a gradual decline from about 6% in 2014 to about 2% in 2017. Injuries by other blunt mechanisms have slightly increased from 3% in 2014 to 5% in 2017. Injuries by other mechanisms including assault/biting, knife/handgun/shotgun/other gun/other penetrating wounds, animal bite/sting, choking/hanging/suffocation, near drowning, and other mechanisms have remained consistent between 2014 and 2017.

Mechanism of Injury	2014	2015	2016	2017	Total
	No (%)	No (%)	No (%)	No (%)	No (%)
MVA/Motorcycle/Bicycle/Pedestrian	1,461 (36.17%)	1,945 (37.75%)	1,904 (40.62%)	1,604 (40.61%)	6,914 (38.78%)
Falls	1,422 (35.2%)	1,716 (33.31%)	1,563 (33.35%)	1,353 (34.25%)	6,054 (33.95%)
Assault/Biting	135 (3.34%)	203 (3.94%)	150 (3.20%)	121 (3.06%)	609 (3.41%)
Other blunt mechanisms	159 (3.93%)	205 (3.97%)	158 (3.37%)	207 (5.24%)	729 (4.08%)
Knife/handgun/shotgun/other gun/other penetrating	136 (3.36%)	190 (3.68%)	194 (4.14%)	131 (3.32%)	651 (3.65%)
Chemical/Inhalation/Thermal/Electric burn/Other burn mechanisms	242 (5.99%)	304 (5.90%)	199 (4.25)	97 (2.46%)	842 (4.72%)
Animal bite/Sting	23 (0.56%)	17 (0.33%)	16 (0.34%)	18 (0.46%)	74 (0.41%)
Choking/Hanging/Suffocation	2	3	1	1	7

	(0.04%)	(0.05%)	(0.02%)	(0.03%)	(0.03%)
Near drowning (submersion)	2 (0.04%)	2 (0.05%)	4 (0.08%)	2 (0.05%)	10 (0.03%)
Others (Glass cuts, Environmental [heat/cold], Hit by falling Object, Machinery, Poisoning, Sexual Assault, Hit by Moving Object)	405 (10.02%)	531 (10.30%)	467 (9.96%)	379 (9.59%)	1,782 (9.99%)
Unknown	52 (1.28%)	35 (0.67%)	31 (0.66%)	37 (0.94%)	155 (0.86%)
Total	4,039 (22.65%)	5,151 (28.89%)	4,687 (26.29%)	3,950 (22.15%)	17,827

Table 3.4 Mechanism of Injury by Year

The two major places where injuries happened were roads and homes (Table 3.5). Over 90% of the motor vehicle injuries happened on roads, while more than half of the falls (54%) happened in homes (Table 3.5). About 30% of injuries occurred at home, and the top three mechanisms of injury at home were burns, falls, and penetrating wounds. Moreover, the majority of the injuries through assault/biting, gunshot/knife injuries, and burns occurred at home. The majority of the other injuries (including cuts from broken glass, environmental [heat/cold], hit by falling/moving object, machinery, poisoning, and sexual assault) occurred at worksites.

Mechanism of Injury	Place of Injury											
	Worksite	Farm	Home	Roads	Desert/Sea	School	Sports	Other public place	Residential institutions	Others	Unknown	Total No (%)
MVA/Motorcycle/Bicycle/ Pedestrian	34 (0.5%)	8 (0.1 %)	157 (2.2%)	6,305 (91.1%)	289 (4.1%)	1 (0%)	3 (0%)	35 (0.5%)	2 (0%)	22 (0.3%)	58 (0.8%)	6,914 (38.78%)
Falls	1,254 (20.7%)	82 (1.3 %)	3,314 (54.7%)	241 (3.9%)	125 (2%)	162 (2.6%)	185 (3%)	312 (5.3%)	42 (0.6%)	115 (1.8%)	222 (3.6%)	6,054 (33.95%)
Assault/Biting	37 (6%)	3 (0.5 %)	334 (54.8%)	97 (15.9%)	11 (1.8%)	14 (2.2%)	0	32 (5.2%)	10 (1.6%)	34 (5.5%)	37 (6%)	609 (3.41%)
Other blunt mechanisms	167 (22.9%)	26 (3.5 %)	257 (35.2%)	11 (1.5%)	45 (6.1%)	14 (1.9%)	74 (10.1%)	28 (3.8%)	4 (0.5%)	30 (4.1%)	73 (10%)	729 (4.08%)
Knife/handgun /shotgun/other gun/other penetrating	176 (27%)	10 (1.5 %)	310 (47.6%)	33 (5%)	18 (2.7%)	6 (0.9%)	3 (0.45%)	22 (3.3%)	3 (0.45%)	37 (5.6%)	33 (5%)	651 (3.65%)
Chemical/Inhalation/Thermal /Electric burn/Other burn	133 (15.7%)	6 (0.7 %)	618 (73.3%)	20 (2.3%)	22 (2.6%)	0	1 (0%)	14 (1.6%)	4 (0.4%)	12 (1.4%)	12 (1.4%)	842 (4.72%)
Animal bite/Sting	10 (13.5%)	21 (28.3 %)	20 (27%)	2 (2.7%)	18 (24.3%)	0	0	0	1 (1.3%)	1 (1.3%)	1 (1.3%)	74 (0.41%)
Choking/Hanging/Suffocation	0	0	7 (100%)	0	0	0	0	0	0	0	0	7 (0.03%)
Near drowning (submersion)	0	0	0	0	7 (70%)	0	0	3 (30%)	0	0	0	10 (0.05%)
Others (Glass cuts/Environmental [heat/cold], Hit by falling Object, Machinery, Poisoning, Sexual Assault, Hit by Moving Object)	1021 (57.2%)	30 (1.6 %)	495 (27.7%)	35 (1.9%)	16 (0.8%)	15 (0.8%)	21 (1.1%)	46 (2.5%)	10 (0.5%)	56 (3.1%)	37 (2%)	1,782 (9.99%)
Unknown	9 (5.8%)	0	63 (40.6%)	14 (9%)	8 (5.1%)	4 (2.5%)	7 (4.5%)	3 (1.9%)	2 (1.2%)	5 (3.2%)	40 (25.8%)	155 (0.86%)
Total **No (%)**	2,841 (15.93 %)	186 (1.04 %)	5,575 (31.27 %)	6,758 (37.90 %)	559 (3.13%)	216 (1.21%)	294 (1.64%)	495 (2.77%)	78 (0.43%)	312 (1.75%)	513 (2.87%)	17,827

Table 3.5 Mechanism of Injury by Place of Injury

Among work-related injuries, falls were the most common mechanism of injury at 42% and over 86% of the work-related injuries occurred at worksites while other 14% injuries occurred in places other than worksites but were also work-related (Table 3.6).

Mechanism of Injury	Place of Injury for Work-Related Injuries											
	Worksite	Farm	Home	Roads	Desert/Sea	School	Sports	Other public place	Residential institutions	Others	Unknown	Total No (%)
MVA/Motorcycle/Bicycle/Pedestrian	17 (13.1%)	2 (1.5%)	2 (1.5%)	101 (78.2%)	4 (3.1%)	0	0	1 (0.7%)	0	1 (0.7%)	1 (0.7%)	129 (4.20%)
Falls	1,174 (89.8%)	32 (2.4%)	33 (2.5%)	14 (1%)	16 (1.2%)	3 (0.2%)	0	19 (1.4%)	1 (0%)	10 (0.7%)	4 (0.3%)	1,306 (42.59%)
Assault/Biting	26 (86.6%)	1 (3.3%)	2 (6.6%)	0	0	0	0	1 (3.3%)	0	0	0	30 (0.97%)
Other blunt mechanisms	155 (80.3%)	20 (10.3%)	4 (2%)	2 (1%)	7	0	0	1 (0.5%)	1 (0.5%)	3 (1.5%)	0	193 (6.29%)
Knife/other gun/other penetrating	163 (87.6%)	3 (1.6%)	7 (3.7%)	0	0	2 (1%)	0	7 (3.7%)	0	4 (2.1%)	0	186 (6.06%)
Chemical/Inhalation/ Thermal/Electric burn/ Other burn mechanisms	122 (86.5%)	0	9 (6.3%)	0	1 (0.7%)	0	0	6 (4.2%)	0	2 (1.4%)	1 (0.7%)	141 (4.59%)
Animal bite/Sting	9 (25%)	14 (38.8%)	3 (8.3%)	0	8 (22.2)	0	0	0	1 (2.7%)	1 (2.7%)	0	36 (1.17%)
Others (Glass cut, Hit by falling Object, Machinery, Poisoning, Sexual Assault, Hit by Moving Object)	973 (93.8%)	14 (1.3%)	19 (1.8%)	5 (0.4%)	2 (0%)	0	0	8 (0.7%)	2 (0%)	6 (0.5%)	8 (0.7%)	1037 (33.82%)
Unknown	7 (87.5%)	0	0	0	1 (12.5%)	0	0	0	0	0	0	8 (0.26%)
Total No (%)	2,646 (86.30%)	86 (2.80%)	79 (2.57%)	122 (3.97%)	39 (1.27%)	5 (0.16%)	0	43 (1.40%)	5 (0.16%)	27 (0.88%)	14 (0.45%)	3,066

Table 3.6 Mechanism of Injury by Place of Injury for Work-Related Injuries

Figure 3.8 depicts annual incidents by ISS categories. Out of the total trauma admissions, over 60% of the cases were ISS category < 9; about 25% cases were ISS categories 9 to 15; about 8% of the cases were ISS categories 16 to 24; and 5% of the cases were admitted with ISS category 25 and above.

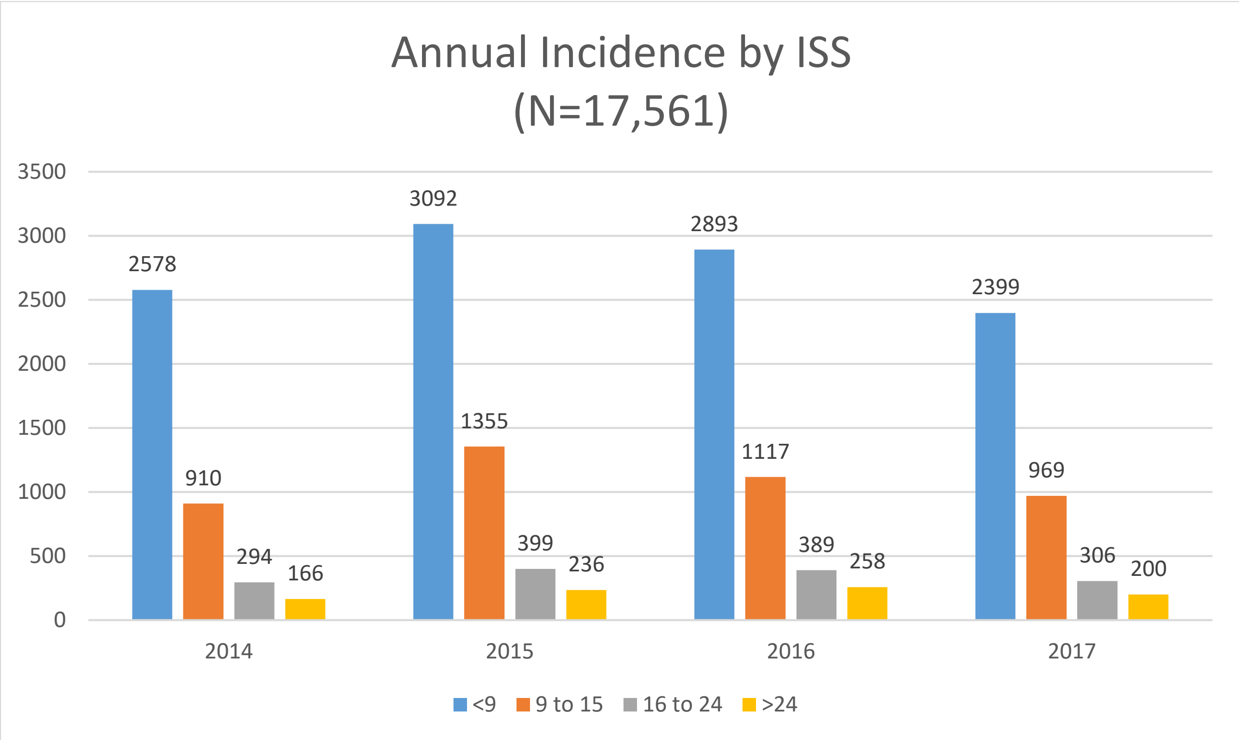


Figure 3.8 Annual Incidence of Severity According to ISS Categories

Table 3.7 provide details on the mechanism of injury by ISS categories. For road traffic injuries, around 53% of the cases were ISS category < 9; about 26% of the cases were ISS category 9 to 15; about 11% of the cases were ISS category 16 to 24; and 8% of the cases were ISS category 25 and above. For patients with falls, around 59% of the cases were admitted with ISS category < 9; about 31% of the cases were ISS category 9 to 15; about 7% of the cases were ISS category 16 to 24; and 2% of the cases were ISS category 25 and above.

Mechanism of Injury	Total	ISS Categories				
		< 9	9–15	16–24	> 24	Unknown
MVA/Motorcycle/Bicycle/Pedestrian	6,914 (38.78%)	3,665 (53%)	1,765 (26%)	789 (11%)	577 (8%)	118 (2%)
Falls	6,054 (33.95%)	3,588 (59%)	1,852 (31%)	414 (7%)	131 (2%)	69 (1%)
Assault/Biting	609 (3.41%)	413 (68%)	126 (21%)	36 (6%)	20 (3%)	14 (2%)
Other blunt mechanisms	729 (4.08%)	563 (77%)	112 (15%)	34 (5%)	10 (1%)	10 (1%)
Knife/handgun/shotgun/other gun/other penetrating	651 (3.65%)	583 (90%)	51 (8%)	5 (<1%)	2 (<1%)	10 (2%)
Chemical/Inhalation/Thermal/Electric burn/Other burn mechanisms	842 (4.72%)	634 (75%)	113 (13%)	25 (3%)	68 (8%)	2 (<1%)
Animal bite/Sting	74 (0.41%)	65 (88%)	7 (9%)	2 (3%)	0	0
Choking/Hanging/Suffocation	07 (0.03%)	3 (43%)	1 (14%)	1 (14%)	1 (14%)	1 (14%)
Near drowning (submersion)	10 (0.03%)	2 (20%)	5 (50%)	0	2 (20%)	1 (10%)
Others (Glass cut, Environmental [heat/cold], Hit by falling Object, Machinery, Poisoning, Sexual Assault, Hit by Moving Object)	1782 (9.99%)	1354 (76%)	294 (16%)	69 (4%)	44 (2%)	21 (1%)
Unknown	155 (0.86%)	101 (65%)	25 (16%)	13 (8%)	5 (3%)	11 (7%)
Total	17,827	10,971 (61.54%)	4,351 (24.40%)	1,388 (7.78%)	860 (4.82%)	257 (1.44%)

Table 3.7 Mechanism of Injury by ISS Category

Table 3.8 depicts the place of injury by ISS categories. For injuries at worksites (Industrial/Construction), over 63% of the cases were ISS category < 9; about 24% of cases were ISS categories 9 to 15; about 8% of the cases were ISS categories 16 to 24; and 5% of the cases were admitted with ISS category 25 and above. For injuries at residential institutions, over 72% of the cases were ISS category < 9; about 14% of cases were ISS categories 9 to 15; about 8% of the cases were ISS categories 16 to 24; and 4% of the cases were admitted with ISS category 25 and above. The highest proportion of patients with ISS category 25 and above were admitted from roads (8%), followed by worksite (5%), deserts/water (4%), and residential institutions (4%).

Place of Injury	**Total**	**ISS Categories**				
		< 9	**9–15**	**16–24**	**> 24**	**Unknown**
Worksite (Industrial/Construction)	2,841 (15.93%)	1,778 (63%)	671 (24%)	225 (8%)	129 (5%)	38 (1%)
Farm	186 (1.04%)	116 (62%)	49 (26%)	16 (9%)	5 (3%)	0
Home	5,575 (31.27%)	3,826 (69%)	1,345 (24%)	240 (4%)	103 (2%)	61 (1%)
Public Roads	6,758 (37.90%)	3,583 (53%)	1725 (26%)	779 (12%)	559 (8%)	112 (2%)
Desert or Water	559 (3.13%)	323 (58%)	146 (26%)	54 (10%)	24 (4%)	12 (2%)
School	216 (1.21%)	155 (72%)	50 (23%)	6 (3%)	2 (1%)	3 (1%)
Sports Facilities	294 (1.64%)	219 (74%)	62 (21%)	4 (1%)	4 (1%)	5 (2%)
Other Public Places	495 (2.77%)	352 (71%)	108 (22%)	20 (4%)	8 (2%)	7 (1%)
Residential Institutions	78 (0.43%)	56 (72%)	11 (14%)	6 (8%)	3 (4%)	2 (3%)
Others	312 (1.75%)	191 (61%)	87 (28%)	18 (6%)	11 (4%)	5 (2%)

Unknown	513 (2.87%)	372 (73%)	97 (19%)	20 (4%)	12 (2%)	12 (2%)
Total	17,827	10,971 (61.54%)	4,351 (24.40%)	1388 (8%)	860 (4.82%)	257 (1.44%)

Table 3.8 Place of Injury by ISS Category

3.4.3 Length of Stay

Overall, the mean length of stay was 6.49 days, ranging between 10.05 days for burn injuries and 3.68 days for blunt injuries. The length of stay was highest for older patients (over 65 years old) at 9.02 days; followed by adults (19–65 years old) at 7.10 days; and lowest for children (0–18 years old) at 4.02 days. The mean length of hospital stays for patients admitted with ISS category > 24 was 24 days; ISS category 16–24 was 12 days; ISS category 9–15 was 7 days; and ISS category < 9 was 3 days (Table 3.9).

Length of Hospital Stay	**Mean Length of Stay**	**Median Length of Stay**
Length of hospital stay by mechanism of injury		
Overall	6.49 days	3 days
MVA/Motorcycle/Bicycle/Pedestrian	7.56 days	3 days
Falls	5.51 days	3 days
Assault/Biting	4.23 days	3 days
Other blunt mechanisms	3.68 days	2 days
Knife/handgun/shotgun/other gun/other penetrating	6.78 days	2 days
Chemical/Inhalation/Thermal/Electric burn/Other burn	10.05 days	5 days
Animal bite/Sting	3.70 days	3 days
Choking/Hanging/Suffocation	3.85 days	1 day
Near drowning (submersion)	3.90 days	4 days
Others (Glass cut, Environmental, Machinery, Poisoning, Hit)	5.58 days	3 days
	6.94 days	2 days

Unknown		
Length of stay by age group		
Children and adolescent (0–18 years)	4.02 days	2 days
Adults (19–65 years)	7.10 days	3 days
Old (> 65 years)	9.02 days	5 days
Length of stay by ISS categories		
< 9	3.96 days	2 days
9–15	7.10 days	4 days
16–24	12.89 days	6 days
> 24	24.81 days	11 days
Length of stay by gender		
Male	6.69 days	3 days
Female	5.72 days	2 days

Table 3.9 Length of Hospital Stay

3.4.4 Mortality

The overall mortality (pronounced dead at discharge) in our sample was 1.41% (Table 3.10). The highest case fatality cause was road traffic injuries (57%), followed by falls (21%), and burns (10%), and others (including glass cut, environmental, machinery, poisoning, and hit by moving object) (5%). Mortality was highest among patients admitted with ISS category > 24 (56%), followed by ISS category16 to 24 (19%) and ISS category 9 to 15 (16%). Mortality was lowest among the patients admitted with ISS category < 9 at about 7%. Figure 3.9 depicts the increasing trend of case fatality with the increasing ISS category, with least mortality among patients with ISS category < 9 and the highest proportion of mortality among patients with ISS category > 24.

Mortality	**Number** **N=17,827**	**Case fatality (%)**
Overall mortality	253	1.41%
Mortality by mechanism of injury		
Total	253	
MVA/Motorcycle/Bicycle/Pedestrian	145	57.3%
Falls	54	21.34%
Assault/Biting	6	2.37%
Other blunt mechanisms	3	1.18%
Knife/handgun/shotgun/other gun/other penetrating	2	0.79%
Chemical/Inhalation/Thermal/Electric burn/Other burn	24	9.48%
Animal bite/Sting	0	0%
Choking/Hanging/Suffocation	1	0.39%
Near drowning (submersion)	1	0.39%
Others (Glass cut, Environmental, Machinery, Poisoning, Hit)	13	5.13%
Unknown	4	1.58%
Mortality by ISS categories		
Total	240	
< 9	18	7.50%
9–15	39	16.25%
16–24	47	19.58%
> 24	136	56.66%
Mortality by gender		
Total	253	
Male	210	1.47%
Female	43	1.21%

Table 3.10 Mortality

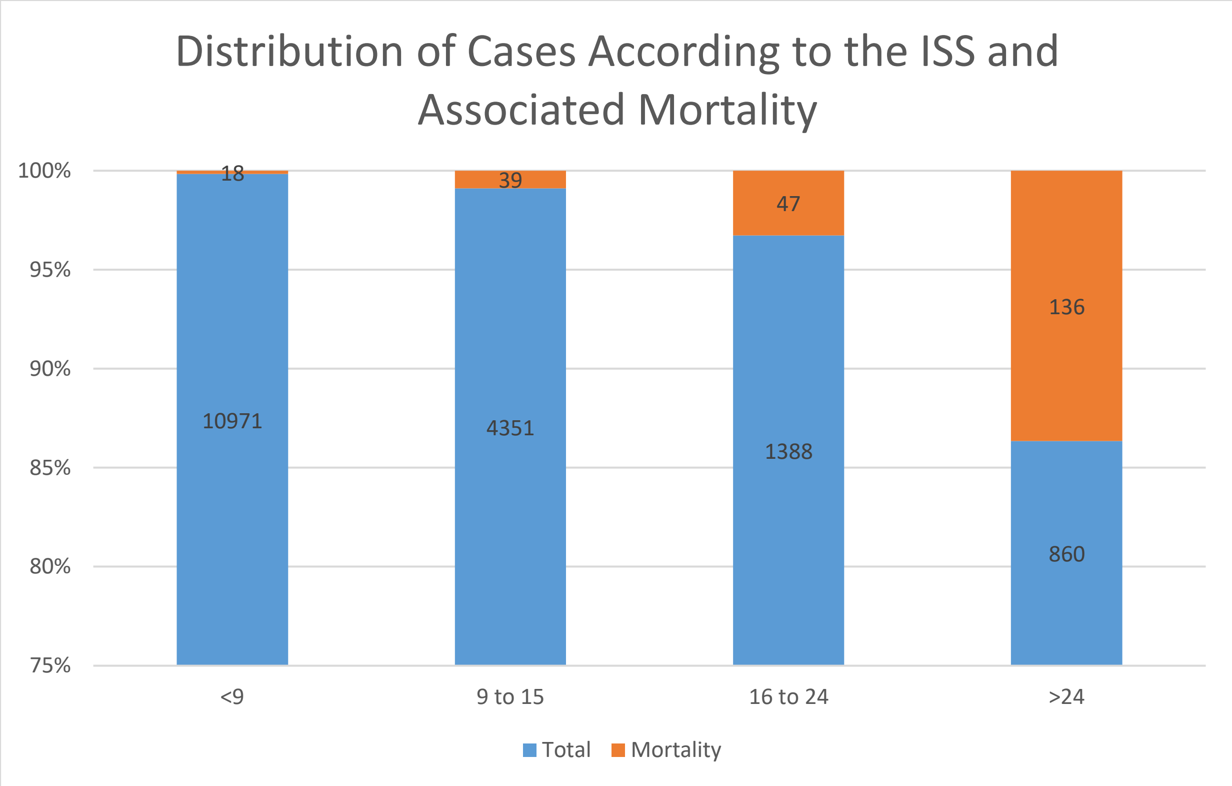


Figure 3.9 Distribution of Cases According to the Injury Severity Score and Associated Mortality in Each Group

Annual mortality for the sample is depicted in Figure 3.10. The mortality between 2014 and 2017 ranged between a lowest of 1.4% (54 deaths out of 3,874 admissions) and a highest of 1.8% (84 deaths out of 4,657 admissions). The mortality rate in 2014 was 1.4% (55 deaths out of 3,948 admissions), in 2015 was 1.18% (60 deaths out of 5,082 admissions), in 2016 was 1.8% (84 deaths out of 4,657 admissions), while the mortality rate in 2017 was 1.39% (54 deaths out of 3,874 admissions).

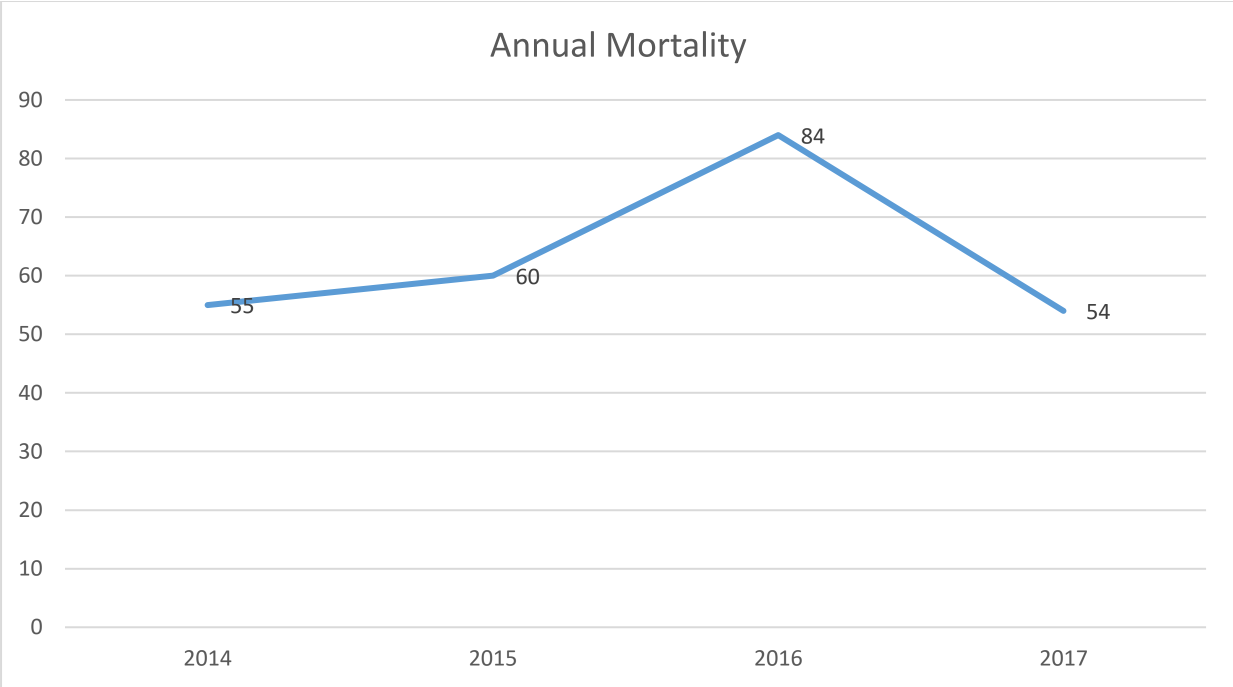


Figure 3.10 Mortality by Time Period (2014–2017)

Table 3.11 depicts mortality by hospital. The data shows that the mortality rates varied among the seven hospitals ranging from the lowest mortality rate of 0% in one hospital to the highest mortality rate of 2.28% in one of the hospitals. The mortality rates in the participating hospitals were reported to be 0.73% in hospital A, 1.37% in hospital B, 1.94% in hospital C, 2.28% in hospital D, 1.69% is hospital E, 1.69% in hospital F, while there was no mortality in Hospital G.

Hospital	**Total Admissions**	**Mortality**	**Case Fatality %**
A	4,779	35	0.73%
B	1,234	17	1.37%
C	2,411	47	1.94%
D	263	6	2.28%
E	5,321	90	1.69%
F	3,427	58	1.69%
G	392	0	0%
Total	17,827	253	1.41%

Table 3.11 Mortality Per Hospital

3.4.5 Regression Analysis

Table 3.12 depicts the regression model for length of stay, age, gender, ISS categories, and mechanism of injury. The overall model was statistically significant (p-value for F-test = 0.0000). Findings from the regression analysis suggest that age and ISS are significantly associated with the length of stay; while gender and mechanism of injury were found not be significantly associated with the length of stay. The model suggests that increasing ISS category (< 9; 9–15; 16–24; > 24) increases the length of hospital stay by 5.8 days with all other variables kept constant. Moreover, increasing age (< 18 years; 19–65 years; > 65 years) leads to an increase in the length of hospital stay by 2.4 days with all other variables kept constant.

Predictor Variables	**Odds Ratios / Linear Coefficient with 95% CI**	**p-value for F-test**
Age		
< 19 years	REF	
19–65 years	3.08 (2.50 to 3.66)	0.000
> 65 years	5.00 (3.75 to 6.25)	
Gender	4.72 (-27.34 to 36.79)	0.017
Mechanism of Injury		
MVA/motorcycle/bicycle/pedestrian	REF	
Falls	-2.04	0.000
Assault/biting	-2.21	
Other blunt mechanisms	-3.88	
Knife/gunshots/other penetrating wounds	-0.78	
All burns	2.49	
Choking/hanging/suffocation	-3.86	
Near drowning	-3.70	
Others	-3.66	
ISS score		

<9 9–15 16–24 >24	REF 3.13 (2.58 to 3.68) 8.92 (8.05 to 9.80) 20.84 (19.75 to 21.93)	0.000

Predictor Variables	Coefficient	Standard Error	p-value	βB
ISS	5.824	0.163	0.000	0.261
Injury Mechanism	0.025	0.014	0.071	0.013
Age	2.413	0.246	0.000	0.071
Gender	0.359	0.299	0.231	0.008

Table 3.12 Linear Regression Model: Predictors of Length of Hospital Stay

Table 3.13 depicts the logistic regression model for mortality suggesting a significant increase in mortality with increasing age compared to a reference group of those < 19 years of age; for the age group 19–65 years the odds increase by 1.77 (OR: 1.77, 95% CI: 1.13 to 2.79); for the age group > 65 years the odds increase by 2.51 (OR: 2.51, 95% CI: 1.21 to 5.21). There was no difference in mortality among male and female patients (OR: 0.91, 95% CI: 0.63 to 1.32). There was a significant increase in mortality with increasing ISS scores, when compared to a reference group of scores < 9; the odds of mortality for the ISS score 9–15 increases by 5.25 (OR: 5.25, 95% CI: 2.97 to 9.26); the odds of mortality for the ISS score 16–24 increases by 19.86 (OR: 19.86, 95% CI: 11.33 to 34.81); and the odds of mortality for score > 24 increases by 99.62 (OR: 99.62, 95% CI: 59.58 to 166.55). However, these findings should be interpreted with caution since the sample size for the higher ISS categories was quite small as evidenced by wider confidence intervals.

For mechanism of injury, keeping the reference category of "others"; there is no change in mortality compared to "others" for MVA/motorcycle/bicycle/pedestrian (OR: 1.10; 95% CI:

0.60 to 2.01); falls (OR: 1.01; 95% CI: 0.53 to 1.91); assault/biting (OR: 1.06; 95% CI: 0.38 to 2.93); Other blunt mechanisms (OR: 0.49; 95% CI: 0.10 to 2.27); knife/gunshots/other penetrating wounds (OR: 1.13; 95% CI: 0.24 to 5.23); choking/hanging/suffocation (OR: 13.54; 95% CI: 0.73 to 248.32); and near drowning (OR: 4.23; 95% CI: 0.35 to 51.18). When compared to "others"; the odds of mortality were higher for all burns (OR: 2.15; 95% CI: 1.03 to 4.51). These findings should also be interpreted with caution since the sample sizes were quite small for animal bite/sting; choking/hanging/suffocation and near drowning (submersion).

Predictor Variables	**Odds Ratio (OR)**	**95% Confidence Intervals (CI)**	**p-value**
Age			
< 18 years*	REF		
19–65 years	1.77	1.13 to 2.79	0.013
> 65 years	2.51	1.21 to 5.21	0.013
Gender			
Females	REF		
Males	0.91	0.63 to 1.32	0.650
Mechanism of Injury*			
Others	REF		
MVA/motorcycle/bicycle/pedestrian	1.10	0.60 to 2.01	0.742
Falls	1.01	0.53 to 1.91	0.974
Assault/biting	1.06	0.38 to 2.93	0.896
Other blunt mechanisms	0.49	0.10 to 2.27	0.109
Knife/gunshots/other penetrating wounds	1.13	0.24 to 5.23	0.871
All burns	2.15	1.03 to 4.51	0.041
Choking/hanging/suffocation	13.54	0.73 to 248.32	0.079
Near drowning	4.23	0.35 to 51.18	0.256
ISS score*			
< 9	REF		
9–15	5.25	2.97 to 9.26	0.000
16–24	19.86	11.33 to 34.81	0.000
> 24	99.62	59.58 to 166.55	0.000

*First category is the reference category for all the odds ratios

Table 3.13 Logistic Regression Model: Predictors of Mortality

3.5 DISCUSSION

3.5.1 Summary of Study Findings

Our study summarises data from large facility-based registries from seven facilities in Abu Dhabi describing regional demographic patterns, trauma mechanisms, injury severity, outcomes, predictors of length of hospital stay, and mortality among trauma patients in Abu Dhabi. Our study included a sample of 17,827 cases.

The findings from our study suggest that the majority of the trauma patients in Abu Dhabi were male and aged 21 to 50 years old. Over 70% of the patients were admitted with the two major mechanisms of injuries: road traffic injuries and falls; public roads and homes were the most common places of injury. Information about the mode of transportation to the hospital was missing for about 70% of patients, reflecting a lack on the part of emergency medical services. Our data suggest a decreasing trend in burn injuries (including chemical, inhalation thermal, electric burns, and other burns) over a period of time from 2014 to 2017. Burn injuries reduced from about 6% of all injuries in 2014 (n=242) to about 2% in 2017 (n=97). Our data also suggest that almost all (90%) of the motor vehicle, motorcycle, bicycle, and pedestrian injuries happened on roads while more than half of the falls (54%) happened in homes.

Our findings suggest that about 30% of injuries occurred at home and the top three mechanisms of injury at home were burns, falls, and assault/biting. Moreover, the majority of the injuries through assault/biting, gunshot/knife injuries, and burns also occurred at home. Homes are usually considered safe places, but these findings imply that efforts need to be made to make homes safer in order to prevent burns, falls, and other penetrating wound injuries occurring at home. Further research will be needed to focus on such findings in more detail.

The majority of the other injuries (including cuts from broken glass, environmental [heat/cold], hit by falling/moving object, machinery, poisoning, and sexual assault) occurred at worksites. About 16% of all injuries were work-related; the mechanism of injury for 44% of the work-related injuries was a fall. There is diversity in the work-related injuries given the presence of domestic workers as part of the community where "work" can be a house or a farm, for example.

Out of the total trauma admissions, the majority of the cases were ISS category < 9; while a quarter of cases were ISS category 9 to 15. This is consistent with the findings from other global scenarios [18–20]. The overall mortality in our sample was 1.41%, with the highest case fatality for road traffic injuries, followed by falls. Mortality ranged between 0% and 2.28% across various hospitals. This could be attributable to the varying rate of admissions in the hospitals; the services these hospitals offer; and the population these hospitals serve.

Our data suggest a significant increase in the length of a hospital stay and mortality with increasing age and ISS score. There was no difference in length of hospital stay or mortality by gender.

3.5.2 Comparison with the Data from the Literature

The findings from our study are in concordance with the studies conducted in similar settings [21–31]. However, variation within the countries of the Middle East cannot be ignored. It is also important to note that the trauma-related mortality in our study was about 1.4%, which is lower in comparison to some similar settings. The death rates due to road traffic injuries per 100,000 people in various Gulf countries have been reported to be around 24.1 per 100,000 in UAE, around 34.7 per 100,000 in Libya, around 23.7 per 100,000 in Qatar [32].

Another systematic review assessing traumatic brain injury mortality in the Middle East reported that the overall median mortality that included all age groups and all injury severity was 10% (interquartile range (IQR) 7.75, 15.75) [33]. The review estimated the overall median mortality for head trauma studies based on emergency admissions as 6% (IQR 3, 18) among all age groups and all injury severities [33]. Another study assessing the epidemiology of head injuries in the UAE reported an overall mortality of 5.9% among patients admitted with head injuries [34]. Moreover, a recent study from Saudi Arabia assessing the patterns of traumatic injuries and predictors of in-hospital mortality in patients admitted to the emergency department reported an overall in-hospital mortality of 4.8% [31].

Globally, the WHO global status report on road safety in 2018 highlights that the number of annual road traffic deaths has reached 1.35 million, making road traffic injuries the leading killer of people aged 5–29 years. The report calls for drastic actions to put safety measures in place to meet any future global target that might be set and save lives [35]. Data from the recent GBD study reported that injuries accounted for 8% of global deaths; moreover, the number of deaths due to injury remained stable between 2007 and 2017, while the death rate from injuries decreased by 13.7% to 57.9 deaths per 100,000 in 2017 [3]. There could be a few different reasons for the low mortality in our sample. First, the data from GBD is a population-based data from GBD countries while our data is from hospital-based trauma registries. Second, the majority of the patients admitted (about 60%) had an ISS score below 9, which could have potentially lowered the mortality in our sample. Third, the lower mortality could also be attributable to missing data in the registry.

Our findings suggest no effect modification on the length of hospital stay or mortality by gender when adjusting for other variables. A few studies from other regions of the world have shown significant associations between gender and post-traumatic intensive care admissions [36–38]. This could be attributable to two factors: the first factor is that these studies have very different population demographics in terms of age, gender distribution, and working environments than Abu Dhabi; second, these settings are culturally different in terms of the working population compared to Abu Dhabi.

3.5.3 Study Strengths and Limitations

Our study describes the most recent and to our knowledge the first ever regional analysis of trauma epidemiology in Abu Dhabi by age group, gender, mechanism of injury, and place of injury. The large study population matches the population in the Emirate of Abu Dhabi, but further studies are needed to evaluate the generalizability of our findings. The results from our study can serve as baseline data for future surveillance efforts to generate policies regarding trauma prevention and management in the region.

Despite the large sample size of our study, there are certain limitations to our study. First, the findings and implications were derived retrospectively from a data registry. Studies based on data registries are often prone to limitations related to the data quality and errors that occur during data collection. Second, for this analysis we used the data from the first four years of the registry, which might be problematic due to the learning curve and other limitations. We believe that future analysis based on the data from our data registry will be of better quality leading to more generalizable analysis and estimates as the data quality improves. Third, not all the injury patients come to the hospital for treatment; many patients with non-fatal injuries might seek care at other outpatient health care settings and hence this data might have missed those cases who seek care at other healthcare facilities rather than hospitals. Fourth, since our study relied on the existing data from a trauma registry, we could not explore variables like trauma-related morbidities, complications, and the long-term consequences impacting the DALYs.

3.5.4 Policy Implications

Our paper reports the current burden of trauma in Abu Dhabi, highlighting the importance of investing in trauma prevention. There is a need to strengthen and expand the coverage of the trauma registry to ensure complete inclusion of all traumas. A systematic review assessing the epidemiology and prevention of trauma in the Middle East suggests that population-based studies on the incidence, mechanism, prevention, and outcome of trauma are not well-documented [5]. Context-specific policies and interventions can only be implemented if there is baseline data and a strong surveillance system to monitor progress.

Efforts should be made toward identifying risk factors and consequent mitigation in order to reduce the burden of trauma. Policy formulation and enforcement related to skills, safety, and training for trauma prevention is needed in order to achieve the SDG targets of reducing the burden of trauma. Home and work safety should be a primary focus over the next few years to ensure adequate preventive measures since much of the focus has already been placed on road traffic injuries. Regulations need to be in place in order to minimise injuries occurring at home and implementation of these regulations should be ensured, including injury prevention and first aid trainings with a focus at home safety.

3.6 CONCLUSIONS

To our knowledge, this paper is the very first analysis of the trauma registry in Abu Dhabi that summarises the regional demographic patterns, trauma mechanisms, injury severity, outcomes, predictors of length of hospital stay, and mortality among trauma patients in Abu Dhabi. Implications from our study can facilitate the planning and the implementation of policies related to trauma prevention in the Emirate.

3.7 REFERENCES

1. *WHO, Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018. 2018.*

2. *James SL, Castle CD, Dingels ZV, Fox JT, Hamilton EB, Liu Z, Roberts NL, Sylte DO, Henry NJ, LeGrand KE, Abdelalim A. Global injury morbidity and mortality from 1990 to 2017: results from the Global Burden of Disease Study 2017. Injury Prevention. 2020 Oct 1;26(Supp 1):i96-114.*

3. *Roth, G.A., et al., Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet, 2018. 392(10159): p. 1736-1788.*

4. *Dahdah, S. and D. Bose, Road traffic injuries: a public health crisis in the middle east and north africa. Transport Notes TRN-4, 2013.*

5. *Asim, M., et al., Blunt traumatic injury in the Arab Middle Eastern populations. Journal of emergencies, trauma, and shock, 2014. 7(2): p. 88.*

6. *Organization, W.H., Eastern Mediterranean status report on road safety: call for action. 2010.*

7. *Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, Abbasi-Kangevari M, Abbastabar H, Abd-Allah F, Abdelalim A, Abdollahi M. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet. 2020 Oct 17;396(10258):1204-22.*

8. *Barss, P., et al., Occupational injury in the United Arab Emirates: epidemiology and prevention. Occupational medicine, 2009. 59(7): p. 493-498.*

9. *Al-Thani, H., et al., Workplace-related traumatic injuries: insights from a rapidly developing Middle Eastern country. Journal of environmental and public health, 2014. 2014.*

10. *Christensen-Rand, E., A.A. Hyder, and T. Baker, Road traffic deaths in the Middle East: call for action. Bmj, 2006. 333(7573): p. 860.*

11. *Wagstaff, A., Poverty and health sector inequalities. Bulletin of the world health organization, 2002. 80: p. 97-105.*

12. *Nantulya, V.M. and M.R. Reich, Equity dimensions of road traffic injuries in low-and middle-income countries. Injury control and safety promotion, 2003. 10(1-2): p. 13-20.*

13. *Assembly, G., Sustainable Development Goals (SDGs), Transforming our world. 2015.*

14. *Nwomeh, B.C., et al., History and development of trauma registry: lessons from developed to developing countries. World journal of emergency surgery, 2006. 1(1): p. 32.*

15. *Zehtabchi, S., et al., Trauma registries: history, logistics, limitations, and contributions to emergency medicine research. Academic Emergency Medicine, 2011. 18(6): p. 637-643.*

16. *StataCorp, L., Stata multilevel mixed-effects reference manual. College Station, TX: StataCorp LP, 2013.*

17. *Allen, M.P., Understanding regression analysis. 2004: Springer Science & Business Media.*

18. *Galvagno Jr, S.M., et al., Correlation between the revised trauma score and injury severity score: implications for prehospital trauma triage. Prehospital emergency care, 2019. 23(2): p. 263-270.*

19. *Rubin, M.L., et al., Prognosis of Six-Month Glasgow Outcome Scale in Severe Traumatic Brain Injury Using Hospital Admission Characteristics, Injury Severity Characteristics, and Physiological Monitoring during the First Day Post-Injury. Journal of neurotrauma, 2019. 36(16): p. 2417-2422.*

20. *Kojima, M., et al., Age-Related Characteristics and Outcomes for Patients With Severe Trauma: Analysis of Japan's Nationwide Trauma Registry. Annals of emergency medicine, 2019. 73(3): p. 281-290.*

21. *Bener, A., et al., Trends and characteristics of injuries in the State of Qatar: hospital-based study. International journal of injury control and safety promotion, 2012. 19(4): p. 368-372.*

22. *Ansari, S., et al., Causes and effects of road traffic accidents in Saudi Arabia. Public health, 2000. 114(1): p. 37-39.*

23. *El-Sadig, M., et al., Road traffic accidents in the United Arab Emirates: trends of morbidity and mortality during 1977–1998. Accident Analysis & Prevention, 2002. 34(4): p. 465-476.*

24. *Mamtani, R., et al., Motor vehicle injuries in Qatar: time trends in a rapidly developing Middle Eastern nation. Injury prevention, 2012. 18(2): p. 130-132.*

25. *Tuma, M.A., et al., Epidemiology of workplace-related fall from height and cost of trauma care in Qatar. International journal of critical illness and injury science, 2013. 3(1): p. 3.*

26. El-Matbouly, M., et al., *Traumatic brain injury in Qatar: age matters—insights from a 4-year observational study. The Scientific World Journal, 2013. 2013.*

27. *Atique, S., et al., Trauma caused by falling objects at construction sites. Journal of trauma and acute care surgery, 2012. 73(3): p. 704-708.*

28. *Al-Shammari, N., S. Bendak, and S. Al-Gadhi, In-depth analysis of pedestrian crashes in Riyadh. Traffic injury prevention, 2009. 10(6): p. 552-559.*

29. *Al-Omari, B.H. and E.S. Obaidat, Analysis of pedestrian accidents in Irbid City, Jordan. Open Transp. J, 2013. 7(1): p. 1-6.*

30. *Al-Rubaee, F.R. and A. Al-Maniri, Work related injuries in an oil field in Oman. Oman medical journal, 2011. 26(5): p. 315.*

31. *Abolfotouh, M.A., et al., Patterns of injuries and predictors of inhospital mortality in trauma patients in Saudi Arabia. Open access emergency medicine: OAEM, 2018. 10: p. 89.*

32. *WHO, Global status report on road safety: time for action. 2009: Geneva, World Health Organization.*

33. *El-Menyar, A., et al., Incidence, demographics, and outcome of traumatic brain injury in the Middle East: a systematic review. World neurosurgery, 2017. 107: p. 6-21.*

34. *Abdullah, A., et al., Epidemiology of head injury in the United Arab Emirates. Ulus Travma Acil Cerrahi Derg, 2012. 18(3): p. 213-218.*

35. *Organization, W.H., Global status report on road safety 2018 (2018). Geneva (Switzerland): WHO, 2019.*

36. *Larsson, E., et al., Impact of gender on post-traumatic intensive care and outcomes. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 2019. 27(1): p. 115.*

37. *Pape, M., et al., Is there an association between female gender and outcome in severe trauma? A multi-center analysis in the Netherlands. Scandinavian journal of trauma, resuscitation and emergency medicine, 2019. 27(1): p. 16.*

38. *Joestl, J., et al., The importance of sex differences on outcome after major trauma: clinical outcome in women versus men. Journal of clinical medicine, 2019. 8(8): p. 1263.*

CHAPTER 4: EPIDEMIOLOGY OF FALLS IN THE EMIRATE OF ABU DHABI: FIRST ANALYSIS OF THE ABU DHABI TRAUMA REGISTRY

4.1 ABSTRACT

4.1.1 Background

Globally, falls have become a major public health concern since falls are the second leading cause of unintentional injury deaths worldwide. Globally, about 37.3 million falls are severe enough to require medical attention annually which cause over 17 million disability-adjusted life years (DALYs).

4.1.2 Methods

This was a retrospective observational study based on the surveillance data from trauma registries of seven emergency departmental units of Abu Dhabi. Data were extracted from the registries for fall cases from all trauma cases presented to seven trauma units in Abu Dhabi between 2014 and 2017. Statistical analysis was performed using STATAIC version 16. Multi-logistic regression was performed to assess the impact of age, gender, type of fall, Injury Severity Score (ISS) on mortality, and length of stay.

4.1.3 Results

A total of 20,562 trauma cases were identified from the trauma registries; after exclusions, a total of 17,827 trauma cases were eligible for inclusion and a total of 6,054 (34%) patients were admitted after falls. The majority of the patients (about 74%) admitted after falls were male. Almost half of the patients were aged 21 years to 50 years of age and about 22% of all the patients admitted after falls were admitted after work-related falls. The two major places falls occurred were *home* (55%) and *workplace* (21%). Over 62% of the patients who fell were expatriates (nationals of countries other than the UAE); the major nationalities were Pakistanis

(15%), closely followed by Indian nationals (10%), and Bangladeshi nationals (9%). Overall, the mean length of stay for patients admitted after falls was 6.49 days; ranging between 3.75 days for falls under 1 meter and 13.68 days for falls over 6 meters. The overall mortality among the patients admitted with falls in our sample was < 1%. Fall height appears to be the main determinant of mortality. Among work-related falls, mortality was about 1% for falls < 6 meters while 8% for falls > 6 meters. Among non-work-related falls, mortality was about 0.5% for falls < 6 meters while 6% for falls > 6 meters. Regression analysis suggests a statistically significant increase in the length of hospital stay with increasing age and increasing ISS score. There was a significant increase in mortality with age (OR: 1.01, 95% CI: 1.00 to 1.03) and ISS score (OR: 4.75, 95% CI: 4.15 to 5.42). Mortality was significantly higher for falls > 6 meters compared to falls < 1 meter and 1–6 meters (OR: 18.38, 95% CI: 5.9 to 48.96).

4.1.4 Conclusion

Our paper presents significant data regarding fall patterns in Abu Dhabi in order to plan and implement policies and procedures related to fall prevention and management in the region.

4.2 INTRODUCTION

4.2.1 Overview of the Global Burden

The World Health Organization (WHO) defines a "fall" as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level [1]. Globally, falls have become a major public health concern since they are the second leading cause of unintentional trauma deaths worldwide [1]. The Global Burden of Disease Study (GBD) concluded that in 2017, falls were the second highest contributor to the disability-adjusted life years (DALYs), preceded only by road injuries [2]. An estimated 646,000 deaths occur as a result of falls every year globally, of which over 80% are in low- and middle-income countries [3]. Falls can be fatal or non-fatal; however, non-fatal falls might incur a great morbidity burden for not only individuals but also countries at large since the injuries could lead to life-long disabilities.

Globally, about 37.3 million falls are severe enough to require medical attention annually, which are attributable to over 17 million DALYs [2]. The proportion of DALYs due to disability is much higher for falls, at about 46.4% [2]. The largest morbidity occurs in people aged 65 years or older, young adults aged 15–29 years, and children aged 15 years or younger.

4.2.2 Burden of Falls in the United Arab Emirates (UAE)

Health epidemiology in the Middle East mirrors the global transition as the leading causes of premature death and disability have changed over time in the Middle East and North Africa region [4]. There has been an increase in the burden caused by non-communicable diseases and a drop in most communicable, newborn, nutritional, and maternal health conditions. In the Middle East, traumatic injuries cause a major burden on the healthcare system. As countries in the Middle Eastern region have become more developed with improved transportation and infrastructure networks, trauma related to road traffic accidents, construction, and petrochemical industries has risen. Economic prosperity and job opportunities have attracted a lot of guest workers to the Gulf countries, and they now constitute a large proportion of the worker industry in these countries, making them vulnerable to work-related injuries and falls [5]. Data from the UAE Population Statistics in 2019 suggest that about 88% of the UAE population are expatriates, with about 27% being from India; 12% being from Pakistan; 7% from Bangladesh; and 5% from the Philippines, followed by other nationalities [6].

In the UAE, the incidence of occupational injury was reported as 136/100,000 workers per year [7]; falls from height were responsible for almost half of these occupational injuries (51%) [8]. However there are wide regional differences within the Middle East in terms of economies, requiring a regional analysis of the situation [9]. Owing to improved access and healthcare, the death rates have decreased; however, the morbidity has increased as evidenced by the increased DALYs, causing a substantial financial burden on the families and the government due to the loss of productivity and the need for medical and welfare services for a longer duration of time. The healthcare systems of several middle-income countries of the Gulf are overburdened with injuries, including falls [10–13]. One study suggested that the annual cost of providing care to patients admitted after falls at the workplace was estimated to be over 4.4 million USD, with a mean cost of $15,735 per patient [14].

To ensure a healthcare system is adequately aligned to a population's true health challenges, policymakers must be able to compare the effects of causes of premature deaths and impaired quality of life. There are only a few reports from the Middle East that describe the pattern of falls and safety measures for those who sustained fall injuries [5, 8, 12].

Moreover, the estimates available might not be a true reflection of the actual magnitude of the problem which might be obscured by issues of under-reporting related to competing priorities and the accessibility of resources [12]. Findings from a review assessing the epidemiology and prevention of falls showed the suboptimal documentation of incidence, mechanism, prevention, and outcome of injuries [13]. Therefore, a region-specific study assessing the epidemiology and burden of falls would help us understand the distribution in the region and strengthen surveillance in order to implement policies related to fall prevention and management. The situation in the UAE is further complicated by the fact that, despite the improvements in the safety standards over the past few decades, the region still has a lot to do in terms of reducing workplace falls [15].

4.2.2 Importance of the Trauma Registry

Trauma registries play a critical role in not only capturing the data and maintaining surveillance but also provide an opportunity to evaluate patient outcomes and generate meaningful facility-based comparisons. Trauma registries are databases used to collect and organize information regarding acute care delivered to patients hospitalised with injuries. The major objective of this repository of information is to assess and improve the efficiency and quality of trauma care at the trauma units or facilities [16]. However, there are certain drawbacks to using trauma registries. Trauma registries in some facilities might not represent true population level data due to differences in case inclusion and exclusion criteria, varying data content, and limited geographic and population coverage [17]. Moreover, concerns regarding the completeness and quality might also limit the utility of trauma registries [16, 17].

For this study, we have utilised the data from the existing trauma registries of seven facilities in Abu Dhabi containing data gathered between 2014 and 2017 in order to describe the epidemiology among patients suffering from fall trauma admitted to hospitals in Abu

Dhabi. This data registry is the first registry of its kind in the region that collects data on trauma patients from multiple facilities in Abu Dhabi.

We aimed to conduct a multi-centre, retrospective, observational study to assess the epidemiology of falls in Abu Dhabi.

4.3 METHODS

4.3.1 Objectives

The broader aim of this study was to determine the epidemiology of falls in patients presenting to seven study facilities based on data from the trauma registries collected between 2014 and 2017. We conducted a multi-centre, retrospective, observational study to assess the epidemiology and burden of falls in Abu Dhabi. The specific objectives of this study are as follows:

1. To describe the trends and demographics of falls over the past four years from seven facilities in Abu Dhabi.
2. To assess the characteristics and mechanisms of falls as well as work-related falls.
3. To assess the factors associated with the length of stay among patients who experienced falls.
4. To assess the factors associated with mortality among patients who experienced falls.

4.3.2 Study Design

This was a retrospective observational study based on the data collected from trauma registries of seven facilities in Abu Dhabi.

4.3.3 Study Setting

Data on trauma cases presenting to seven facilities in Abu Dhabi between 2014 and 2017 were extracted from the registries. The inclusion and exclusion criteria were used to identify the cases.

Study inclusion criteria were:

- Each trauma registry's inclusion criteria:

- Includes at least one code within the range of the following injury diagnostic codes: as defined in the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) 800–959.9
- Include one of the following criteria:
    - Hospital admission OR
    - Patient transfer via emergency medical service transport (including air ambulance from one hospital to another hospital) OR
    - Death resulting from traumatic injury (independent of hospital admission or hospital transfer status).
    - Out of the trauma patients who fulfilled the above inclusion criteria, trauma patients who fell were included for this study.

Study exclusion criteria per the trauma registry were:

- All diagnostic codes within the following code ranges:
    - 905–909.0 (late effects of injuries)
    - 910–924.9 (superficial injuries including blisters, contusions, abrasions, insect bites, etc.)
    - 930–939.9 (foreign bodies)

The total number of beds in these facilities ranged from hospitals with less than 200 beds to hospitals with over 600 beds, capacity contributing to a total of 2,551 beds. Facilities were either public; private; or military. Facilities were distributed among the Abu Dhabi regions; the main Island; the Eastern Region; and Al Dhafra Region. For details on the facilities, please see Table 4.1.

Facility Characteristic	*Number (%)*
No. of hospitals submitted data	7
No. of facilities by bed size:	
> 200	1 (14.2%)
201–400	2 (28.5%)
401–600	3 (42.8%)
> 600	1 (14.2%)
Total number of beds	2551
Types of facilities	
Public facilities	5 (71.4%)
Private facilities	1 (14.2%)
Military facility	1 (14.2%)
Facilities by region:	
Abu-Dhabi Island	2 (14.2%)
Abu-Dhabi Region	2 (28.5%)
Eastern Region	1 (14.2%)
Al-Dhafra Region	2 (28.5%)

Table 4.1 Facility Information

4.3.4 Data Sources and Collection

The following data were extracted for each case: demographics (age, gender, ethnicity, and mode of transportation); emergency visit information (time, day, month, and facility); type of fall (fall distance under 1 meter; fall distance between 1–6 meters; and fall distance greater than 6 meters); Injury Severity Score (ISS); patient disposition (discharged, intensive care unit days, ventilator days, and step days); length of stay; and mortality.

4.3.5 Statistical Analysis

Statistical analysis was performed using STATAIC version 16 [18]. Dichotomous data are presented as frequencies and percentages while continuous data are presented as means and standard deviations (SD). Multiple-logistic regression was performed to assess the impact of age, gender, type of fall, and ISS score on mortality and length of stay. Statistical significance was set as $p < 0.05$. Univariate analysis was performed with the Mann-Whitney U test, bivariate analysis with the chi-square test, and multivariate logistic regression using binomial regression [19]. We have reported the findings for regression as odds ratios (OR) with 95% confidence intervals (CI) for mortality and linear coefficients with 95% CI for length of hospital stay.

4.3.6 Institutional Review Board (IRB) Approval

Institutional Review Board (IRB) Approval for the study was obtained from the Zayed Military Hospital, Abu Dhabi.

4.4 RESULTS

These results summarise data from large facility-based registries from seven facilities in Abu Dhabi describing regional demographic patterns of fall injuries; types of falls; outcomes and predictors of length of hospital stay; and mortality among fall patients in Abu Dhabi. Figure 4.1 provides details of the participant enrolment. A total of 20,562 trauma cases were identified from the trauma registries; data were excluded for 2,664 cases from those facilities which were unable to participate in the study. Data for 71 patients were excluded since the data were incomplete. Out of 17,827 cases eligible after exclusions, a total of 6,054 (34%) cases were admitted after falls (Figure 4.2). Distribution of patients according to the year and facility is presented in Table 4.2.

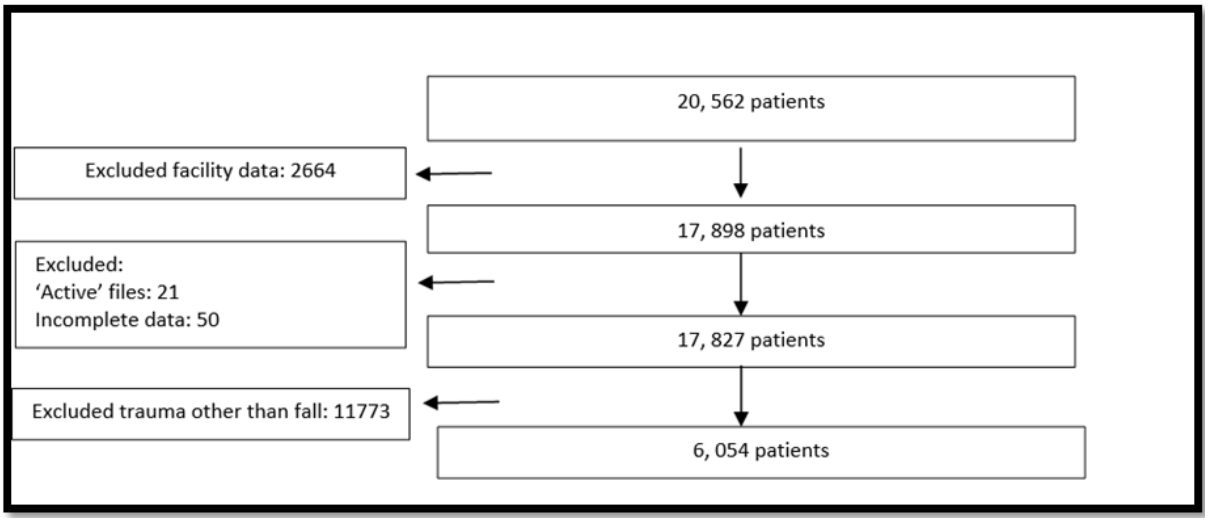


Figure 4.1 Participant Enrolment and Flow of Participants

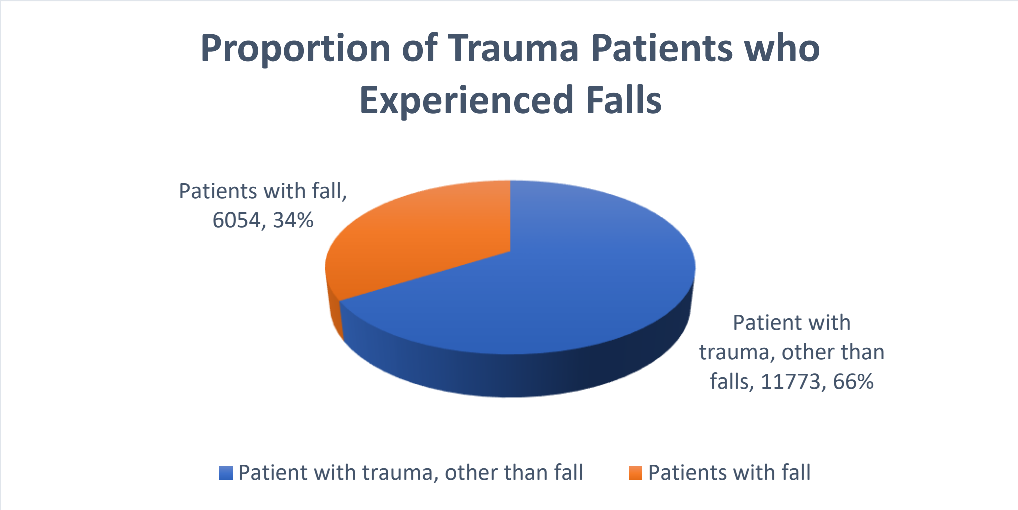


Figure 4.2 Proportion of Trauma Patients Who Experienced Falls

Hospitals	2014			2015			2016			2017			Total		
	Trauma admission	Fall admission	Rate per 1000	Trauma admission	Fall admission	Rate per 1000	Trauma admission	Fall admissions	Rate per 1000	Trauma admissions	Fall admissions	Rate per 1000	Trauma admissions	Fall admissions	Rate per 1000
A	1,009	398	394.4	1,180	459	388.9	1,222	461	377.2	1,368	553	404.2	4,779	1871	391.5
B	202	54	267.3	325	75	230.7	394	106	269.0	313	79	252.3	1,234	314	254.4
C	566	163	287.9	613	176	287.1	646	216	334.3	586	199	339.5	2,411	754	312.7
D	18	3	166.6	178	29	162.9	59	11	186.4	8	0	0	263	43	163.4
E	1369	404	295.1	1,851	522	282	1,322	312	236	779	149	191.2	5,321	1,387	260.6
F	794	370	465.9	913	424	464.4	929	408	439.1	791	337	426.0	3,427	1,539	449.0
G	81	30	370.3	91	31	340.6	115	49	426.0	105	36	342.8	392	146	372.4
Totals	4,039	1,422	352.0	5,151	1,716	333.1	4,687	1,563	333.4	3,950	1,353	342.5	17,827	6,054	339.5

Table 4.2 Overall Admissions and Rate of Fall Admissions

4.4.1 Demographics and Baseline Characteristics

The baseline characteristics of the participants are outlined in Table 4.3. The majority of the patients (about 75%) were male. Almost third of the patients were aged 31 to 50 years old with nearly 20% aged 20–30 years old. About 22% of all the patients admitted to hospitals after falls were admitted with work-related falls. The two major locations where falls occurred were *home* (55%) and *workplace* (21%). The majority of falls were admitted with ISS category < 9 (59%); about 30% of the patients were admitted with an ISS score of 9 to 15; about 6% of the patients had an ISS score of 16 to 24; and 2% of the patients were admitted with an ISS score of over 25.

The gender and age distribution of the study population as compared to the overall population of Abu Dhabi is depicted in Figure 4.3. Over 62% of the patients who experienced a fall were expatriates (nationals of countries other than the UAE); the major nationalities were from Pakistan (15%), closely followed by Indian nationals (10%), and Bangladeshi nationals (9%) (see **Appendix** Figure 1).

Characteristics	**Number (%)** **N=6,054**
Total patients	
2014	1,422 (23.45%)
2015	1,716 (28.34%)
2016	1,563 (25.81%)
2017	1,353 (22.34%)
Missing	0%
Gender	
Male	4,501 (75%)
Female	1,553 (25%)
Missing	0%

Age distribution	
< 1 year	140 (2.31%)
2–10 years	1,107 (18.28%)
11–20 years	598 (9.87%)
21–30 years	1,205 (19.90%)
31–40 years	1,123 (18.54%)
41–50 years	662 (10.93%)
51–60 years	422 (6.97%)
61–70 years	348 (5.74%)
>70 years	449 (7.41%)
Missing	0%
Patient nationality	
UAE national	2,055 (34%)
Other nationals	3,738 (62%)
Missing	266 (4%)
Work related falls (*)	1,306 (21.57%)
Missing	91 (1.50%)
Type of Fall	
Fall under 1 meter	1,221 (20.16%)
Fall 1–6 meters	1,422 (23.48%)
Fall over 6 meters	313 (5.17%)
Fall - NFS	3,098 (51.17%)
Place of fall	
Home	3,314 (54.74%)
Workplace	1,254 (20.71%)
Other public places	312 (5.15%)
Public road	241 (3.98%)
Sports facility	185 (3.05%)
School	162 (2.67%)

Desert/Sea	125 (2.06%)
Other	115 (1.89%)
Farm	82 (1.35%)
Residential institutions	42 (0.69%)
Missing	227 (3.74%)
Length of hospital stay (days)	Median: 3 days; Mean: 6.49 days
0–3 days	3,666 (60.55%)
4–7 days	1,328 (21.93%)
8–15 days	695 (11.48%)
16–30 days	239 (3.94%)
> 30 days	113 (1.86%)
Missing	18 (0.29%)
ISS score	Median: 4; Mean: 7.4
ISS Category	
< 9	3,588 (59.26%)
9–15	1,852 (30.59%)
16–24	414 (6.83%)
> 24	131 (2.16%)
Missing	69 (1.13%)
ICU days (mean)	1.67 days
Ventilator days (mean)	1.11 days
Step days (mean)	4.99 days
Blood or blood products requirement according to ISS categories	196 (3.23%)
Total	26 (13.26%)
< 9	106 (54.08%)
9–15	27 (13.77%)
16–24	27 (13.77%)
> 24	10 (5.10%)

Missing	
Mortality by ISS categories	
Overall mortality	53 (0.87%)
< 9	5 (9.4%)
9–15	13 (24.52%)
16–24	14 (26.41%)
> 24	21 (39.62%)

* Indication of whether the injury occurred during paid employment.

** Use of alcohol by patient as assessed by blood alcohol concentration (BAC).

Table 4.3 Demographics of the Study Population

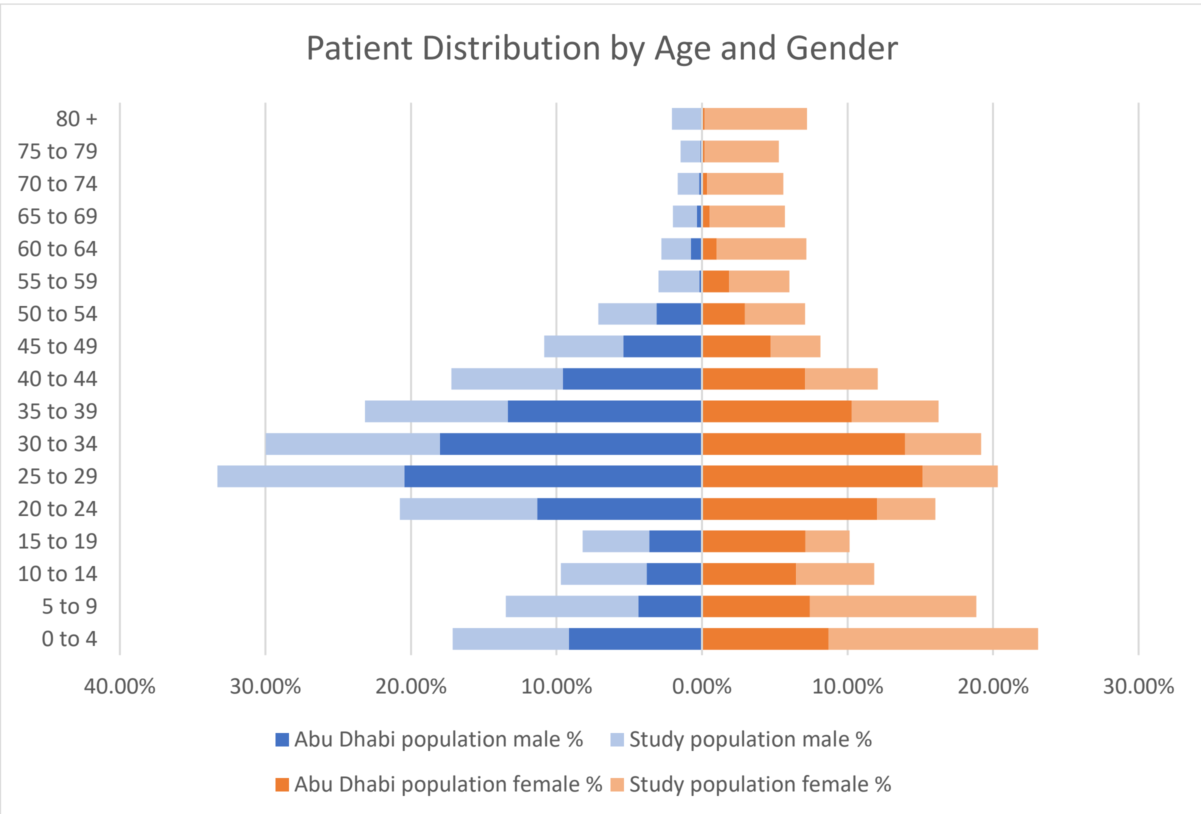


Figure 4.3 Study Patient Distribution Compared to Abu Dhabi's Population Distribution by Age and Gender

4.4.2 Fall Characteristics

Figure 4.4 shows the distribution of patients with falls by year and facility.

Figure 4.5 shows the annual influx of patients according to the time of the day, day of the week, and month of the year. The maximum influx of patients was between 1200 hours to midnight while the influx remained lowest between 0300 and 0600.

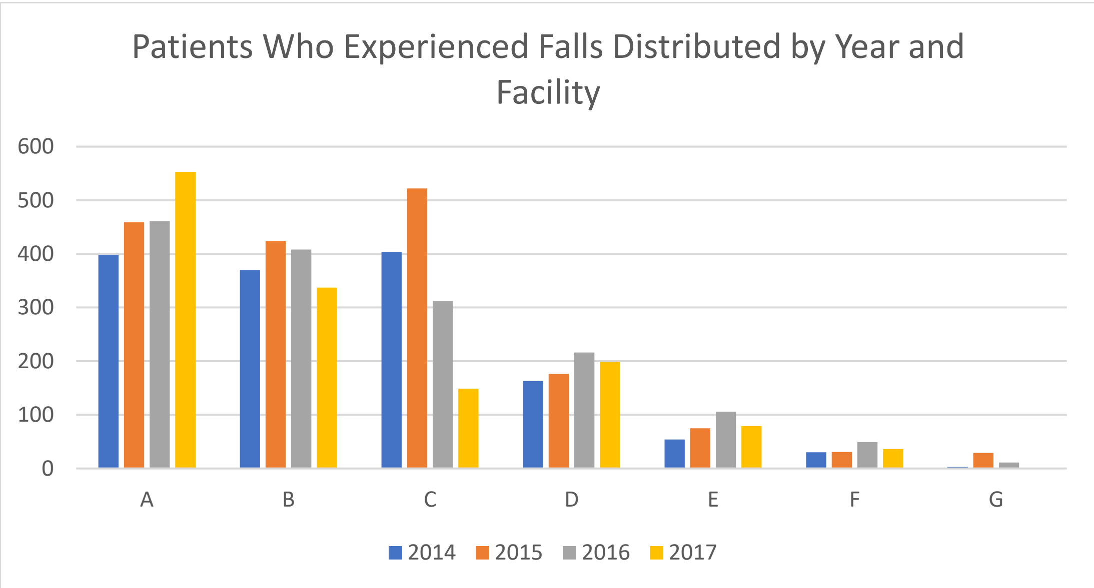
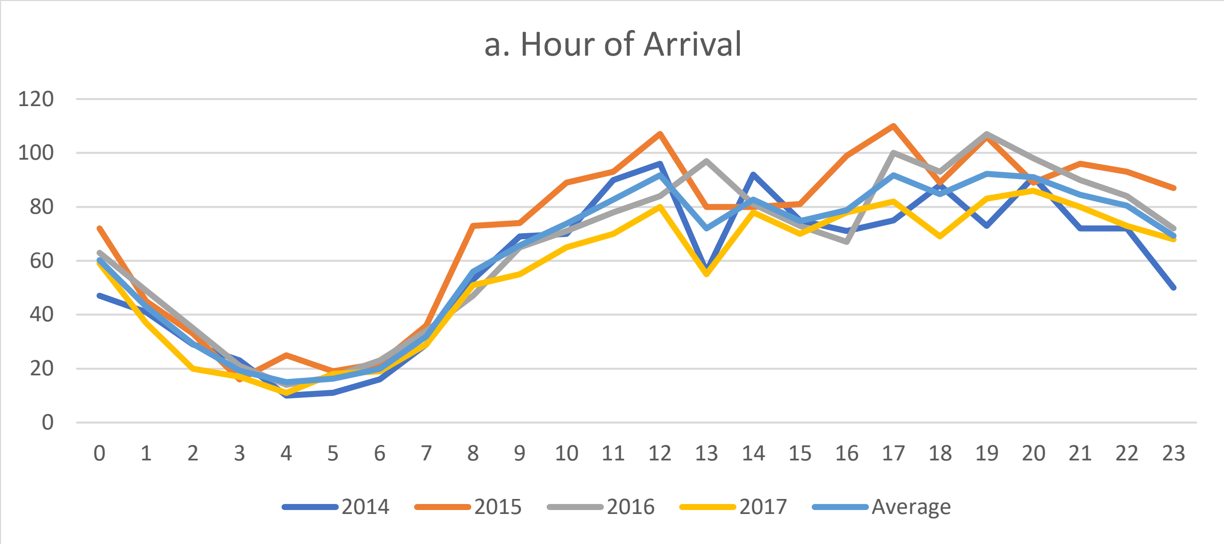
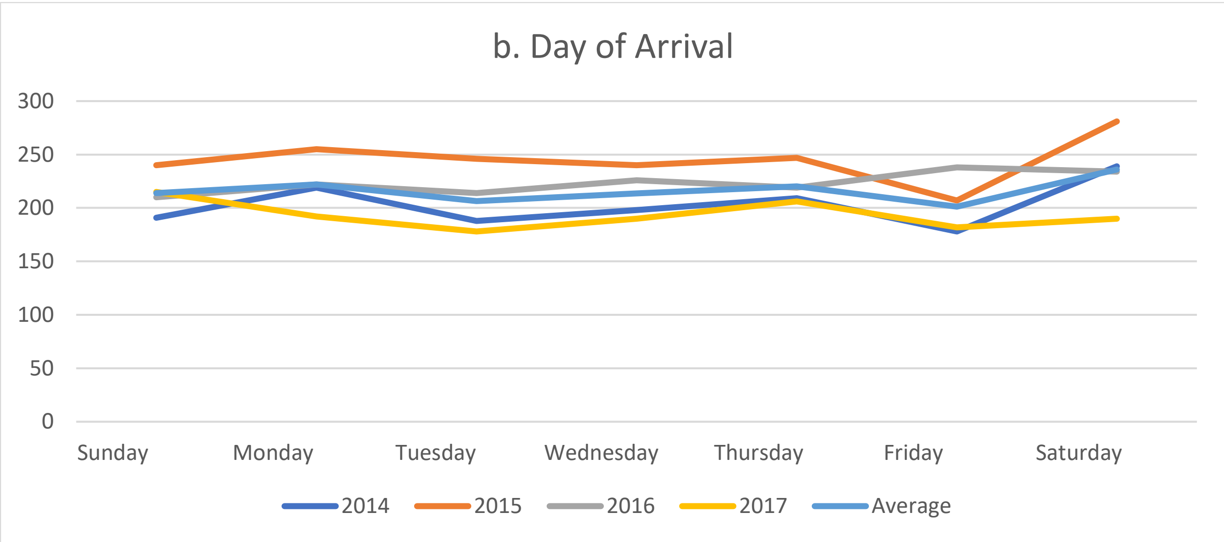


Figure 4.4 Patients With Fall By Year and Facility


a. Hour of Arrival
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
2014
2015
2016
2017
Average


b. Day of Arrival
300
250
200
150
100
50
0
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
2014
2015
2016
2017
Average

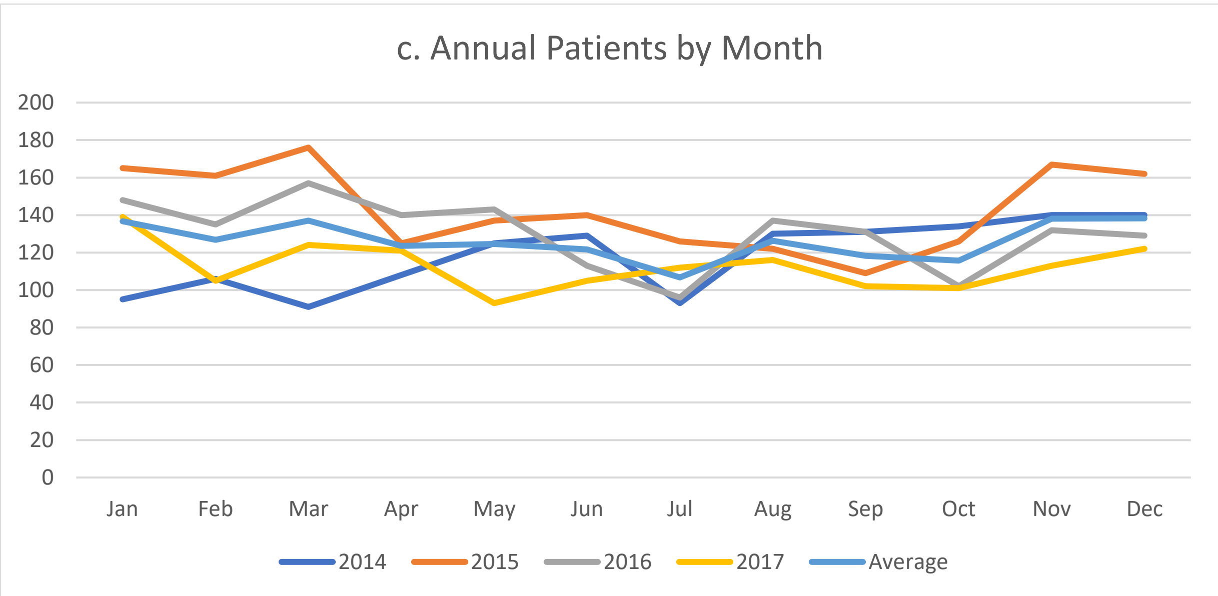

c. Annual Patients by Month
200
180
160
140
120
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2014
2015
2016
2017
Average

Figure 4.5 Patient Influx (a. Hour of Arrival; b. Day of Arrival; c. Month of Arrival)

Table 4.4 depicts place of injury by ISS categories. The place of fall for almost 55% of the patients was *home* while *worksite* was the place of injury for about 21% of the patients. In terms of ISS categories, the proportion of patients admitted with an ISS > 24 was highest among worksite locations (including industrial and construction sites, at about 6%), followed by residential institutions (about 5%), and public roads (about 3%).

Figure 4.6 depicts the annual incidence of falls by ISS categories.

Place of Injury	Total	ISS Categories				
		< 9	9–15	16–24	> 24	Unknown
Worksite (Industrial/Construction)	1,254 (20.71%)	618 (49.2%)	391 (31.1%)	153 (12.2%)	70 (5.5%)	22 (1.7%)
Farm	82 (1.35%)	46 (56%)	25 (30.4%)	9 (10.9%)	2 (2.4%)	0
Home	3,314 (54.74%)	1,994 (60.1%)	1070 (32.2%)	180 (5.4%)	36 (1%)	34 (1%)
Public Roads	241 (3.98%)	144 (59.7%)	68 (28.2%)	19 (7.8%)	7 (2.9%)	3 (1.2%)
Desert or Water	125 (2.06%)	79 (63.2%)	30 (24%)	12 (9.6%)	2 (1.6%)	2 (1.6%)
School	162 (2.67%)	115 (70.9%)	42 (25.9%)	5(3%)	0	0

Sports Facilities	185 (3.05%)	135 (72.9%)	44 (23.7%)	3 (1.6%)	1 (0.5%)	2 (1%)
Other Public Places	312 (5.15%)	214 (68.5%)	82 (26.2%)	11 (3.5%)	3 (1%)	2 (0.6%)
Residential Institutions	42 (0.69%)	31 (73.8%)	4 (9.5%)	5 (11.9%)	2 (4.7%)	0
Others	115 (1.89%)	64 (55.6%)	38 (33%)	8 (6.9%)	4 (3.4%)	1 (0.8%)
Unknown	222 (3.74%)	148 (66.6%)	58 (26.1%)	9 (4%)	4 (1.8%)	3 (1.3%)

Table 4.4 Place of Injury By ISS Category

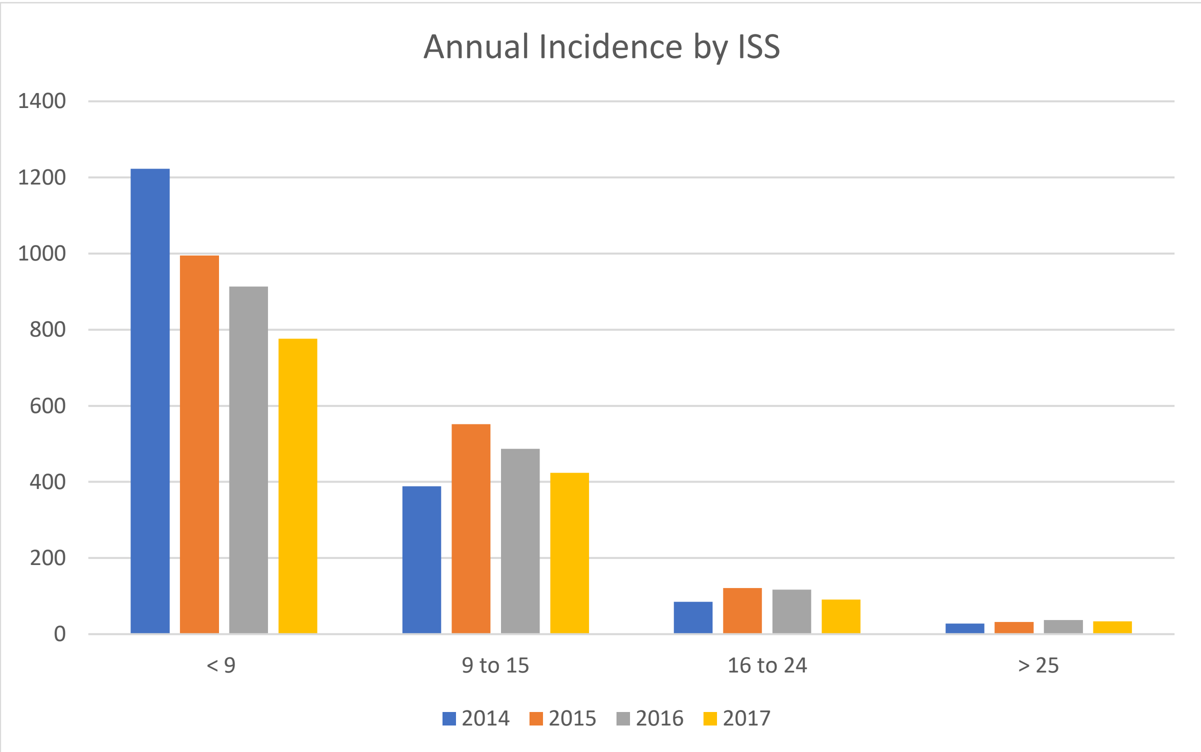


Figure 4.6 Annual Incidence of Severely According to ISS Categories

4.4.3 Length of Stay

Overall, the mean length of stay for patients admitted after a fall was 6.49 days; ranging between 3.75 days for falls under 1 meter and 13.68 days for falls over 6 meters. The length of stay was highest for older patients (> 65 years old) at 8.84 days; followed by adults (19–65 years old) at 6.3 days; and lowest for children (0–18 years old), at 2.63 days.

The length of hospital stays for patients admitted with ISS category > 24 was 25.7 days; ISS category 16–24 was 12.23 days; ISS category 9–15 was 6.23 days; and ISS category < 9 was 3.57 days (see Table 4.5).

Length of hospital stay	**Mean length of Stay**	**Median length of stay**
Length of hospital stay by fall type		
Fall under 1 meter	3.76 days	2 days
Fall 1–6 meters	6.56 days	3 days
Fall over 6 meters	13.68 days	6 days
Fall - NFS	4.90 days	3 days
Length of stay by age group		
Children and adolescent (0–18 years)	2.63 days	2 days
Adults (19–65 years)	6.30 days	3 days
Old (>65 years)	8.84 days	5 days
Length of stay by ISS categories		
< 9	3.57 days	2 days
9–15	6.23 days	4 days
16–24	12.23 days	5.5 days
> 24	25.71 days	11 days

Table 4.5 Length of Hospital Stay

4.4.4 Mortality

The overall mortality among the patients admitted with falls in our sample was approximately 1%. Among work-related falls, mortality was about 1% for falls from distances < 6 meters but increased to 8% for falls from distances > 6 meters. Among non-work-related falls, mortality was about 0.5% for falls < 6 meters but increased to 6% for falls > 6 meters (see Table 4.6). The annual rate of overall mortality and work-related fall mortality was similar throughout the four years (Figure 4.7). Height appears to be the major determining factor for mortality among patients admitted after experiencing falls (see Table 4.7). Mortality within each ISS category was higher for falls > 6 meters compared to falls < 6 meters.

	Type of Fall			
	Fall < 6 meters **N=2643**		**Fall > 6 meters** **N=313**	
	Number (%)	**Mortality (%)***	**Number (%)**	**Mortality (%)***
Work-related falls	814 (30.79%)	8 (0.98%)	201 (64.21%)	16 (7.96%)
Non-work-related falls	1,798 (68.02%)	9 (0.50%)	108 (34.50%)	6 (5.55%)
Unknown	31 (1.17%)	0	4 (1.27%)	0

Table 4.6 Work-Related and Non-Work-Related Mortality by Type of Fall

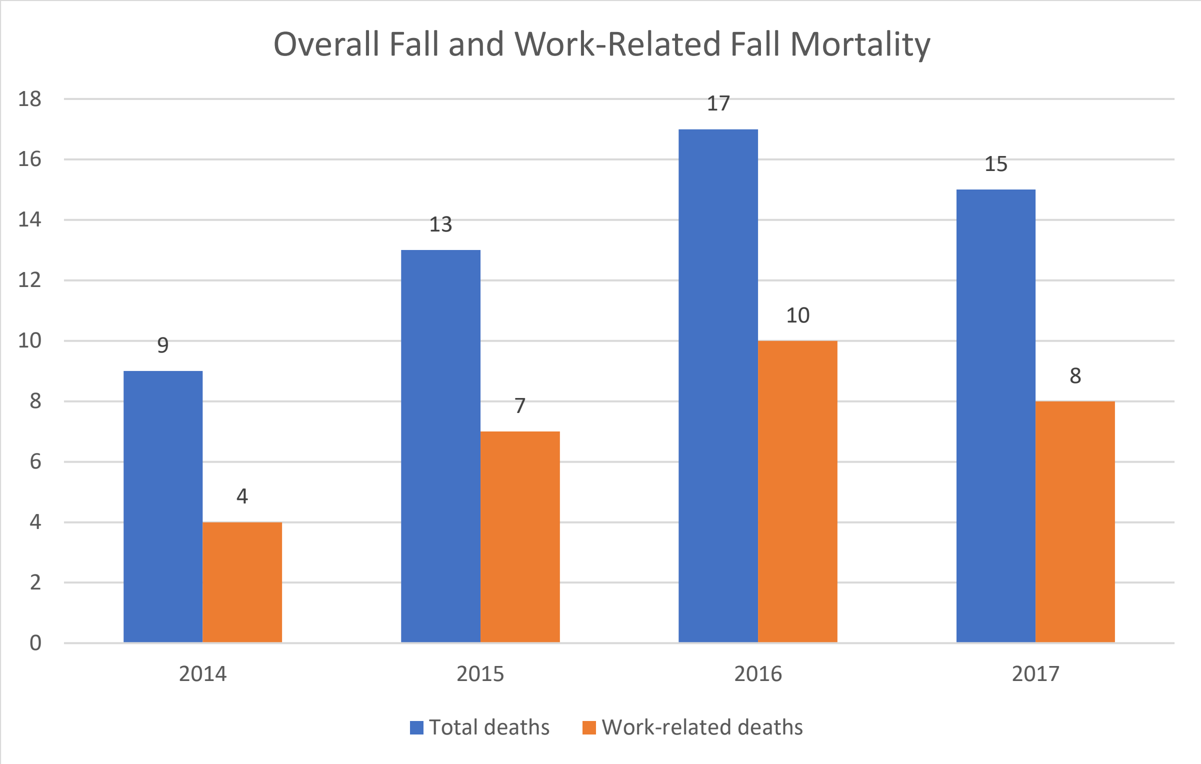


Figure 4.7 Overall Fall Mortality and Work-Related Mortality

	Type of fall			
ISS Category	**Fall < 6 meter** **N=2643**		**Fall > 6 meter** **N=313**	
	Total	**Mortality (%)***	**Total**	**Mortality (%)***
< 9	1,434	1 (0.06%)	103	2 (1.94%)
9 to 15	882	4 (0.45%)	108	4 (3.7%)
16 to 24	228	5 (2.19%)	51	4 (7.84%)
> 24	65	6 (9.23%)	42	12 (28.57%)
Total	2,643	16 (0.6%)	313	22 (7.02%)

Table 4.7 Fall-Related Mortality by Type of Fall and ISS Category

Figure 4.8 depicts the distribution of falls according to ISS category and associated mortality. The mortality was the highest among fall patients admitted with an ISS score > 24 (16%), followed by patients admitted with an ISS score between 16 and 24 (3%), an ISS score between 9 and 15 (0.7%), and the lowest among patients with ISS score < 9.

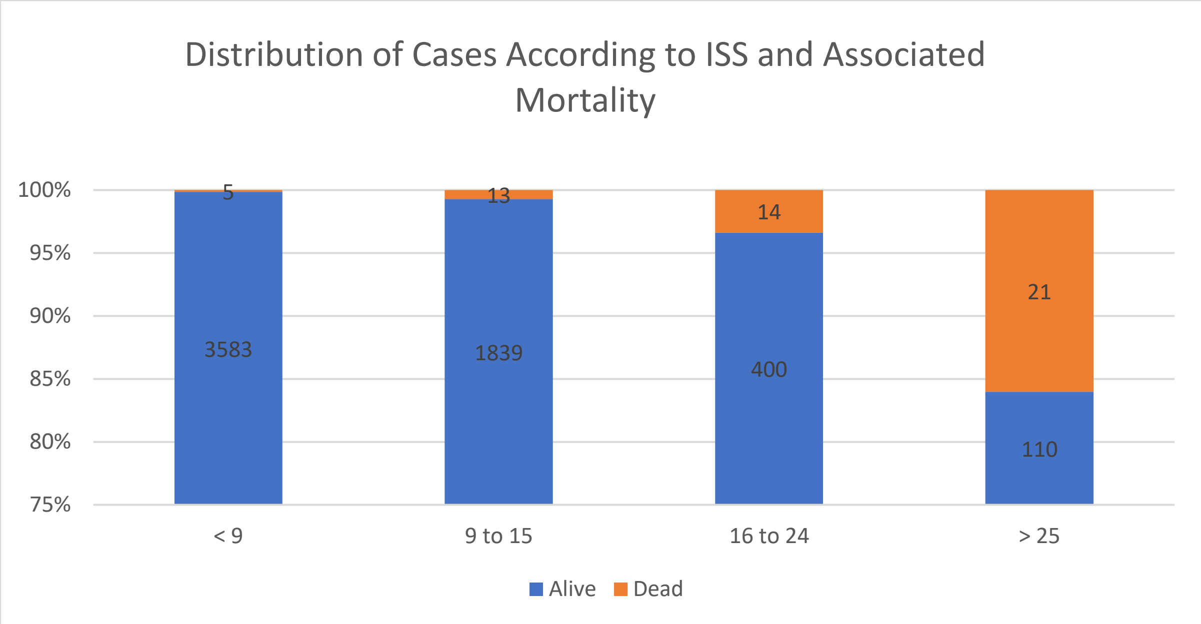


Figure 4.8 Distribution of Cases According to the ISS and Associated Mortality in ISS Category

4.4.5 Regression Analysis

Table 4.8 depicts the regression model for the length of the patient's stay. The overall model was statistically significant (p-value for F-test = 0.000). Findings from the regression analysis suggest that increasing ISS category (< 9; 9–15; 16–24; > 24) increases the length of hospital stay by 4.48 days with all other variables kept constant. Increasing age (< 18 years; 19–65 years; > 65 years) leads to an increase in the length of hospital stay by 8.46 days with all other variables kept constant. Increasing height of fall also leads to an increase in length of stay by 1.45 days with all other variables kept constant.

Predictor Variables	Coefficient	Standard Error	p-value	β
ISS	4.48	0.37	0.000	0.147
Type of Fall	1.45	0.23	0.000	0.077
Age	8.46	0.48	0.000	0.216
Gender	3.01	0.65	0.000	0.056

Table 4.8 Linear Regression Model: Predictors of Length of Hospital Stay

Table 4.9 depicts the logistic regression model for mortality, suggesting significant increases in mortality with increasing height of the fall and ISS score. With the reference group of falls under 1 meter, the odds of mortality from height over 6 meters increased by 5.48 (OR: 5.48, 95% CI: 1.78 to 16.80) while there was no difference in the odds of mortality between falls under 1 meter and falls between 1–6 meters. With the reference category of ISS score of < 9, the odds of mortality significantly increased for the ISS category 9 to 15 by 3.55 (OR: 3.55; 95% CI: 1.24 to 10.18); the odds of mortality increased by 17 for the ISS category 16–24 (OR: 17; 95% CI: 5.92 to 48.84); the odds of mortality increased by 45.37 (OR: 45.37; 95% CI: 16.09 to 127.96) for the ISS category > 24. There was no difference among females and males (OR: 0.39; 95% CI: 0.15 to 1.01). Our model did not show any impact of age on the odds of mortality once controlling for other variables. These findings should be interpreted with caution due to the small number of events in our sample size.

Predictor Variables	Odds Ratio (OR)	95% Confidence Intervals (CI)	p-value
Age			
< 19 years	REF		
19–65 years	0.39	0.15 to 1.01	0.06
> 65 years*	-	-	-
Gender			
Females	REF		
Males	1.41	0.58 to 3.38	0.441
Type of fall			
Fall under 1 meter	REF		
Fall 1–6 meters	1.06	0.33 to 3.38	0.918
Fall over 6 meters	5.48	1.78 to 16.80	0.003
Fall - NFS	1.27	0.45 to 3.58	0.650
ISS score			
< 9	REF		
9–15	3.55	1.24 to 10.18	0.018
16–24	17.00	5.92 to 48.84	0.000
> 24	45.37	16.09 to 127.96	0.000

* Values too low for Odds calculation

Table 4.9 Logistic Regression Model: Predictors of Mortality

4.5 DISCUSSION

4.5.1 Overview of Fall Burden

Our study summarises data from large facility-based registries from seven facilities in Abu Dhabi describing regional demographic patterns of fall injuries, types of falls, outcomes, and predictors of length of hospital stay, and mortality among fall patients in Abu Dhabi. Our study included a sample of 17,827 eligible trauma patients, out of which a total of 6,054 (34%) cases were admitted after a fall. The majority of the patients (about 74%) admitted after falls were male. Almost half of the patients were aged 21 to 50 years of age and about 21% of all patients admitted after falls were admitted with work-related falls. The two major locations where falls occurred were *home* (55%) and *workplace* (21%). Over 62% of the patients with falls were expatriates (nationals of countries other than the UAE); the major nationalities were Pakistani nationals (15%), followed closely by Indian nationals (10%), and Bangladeshi nationals (9%).

4.5.2 Summary of Main Findings

Findings from our study suggest that the overall mean length of stay for patients admitted with falls was 6.49 days; ranging between the lowest mean number of days of stay (3.75 days) for falls under 1 meter and the highest mean number of days of stay (13.68 days) for falls over 6 Meters. The place of fall for almost 55% of the patients was home while worksite was the place of injury for about 21% of the patients.

In our sample, the overall mortality among the patients admitted after a fall was approximately 1%, which is lower compared to other countries; this could be attributable to the fact that patients with severe fall injuries might have died before arriving at the hospital.

The height of the fall appears to be the major determinant of mortality since mortality within each ISS category was higher for falls > 6 meters compared to falls < 6 meters. Among work-related falls, mortality was about 1% for falls < 6 meters while 8% for falls > 6 meters. Among non-work-related falls, mortality was about 0.5% for falls < 6 meters while 6% for falls > 6 meters. Regression analysis suggests a statistically significant increase in the length of hospital stay with increasing age and increasing ISS score. Mortality was significantly higher for falls > 6 meters compared to falls < 1 meter and 1–6 meters.

4.5.3 Comparison with the Data from the Literature

Despite the scarcity of regional literature on the burden and distribution of falls, our findings are in concordance with the few other existing studies in the region [3, 14, 20–27]. A systematic review assessing the epidemiology of injuries in the Middle East has reported falls from height as the second most common mechanism of injury in the region [13]. A study examining the mechanisms, risk factors, and outcomes of hospitalized patients with fall-related injuries at one of the facilities in the UAE reported that falls were a major public health concern and the most common location for fall injuries was work [28]. The same study also reported that the patients sustaining fall injuries at work were older and mainly non-UAE nationals [28]. An occupational injury surveillance study for all work related injury patients between 2010 and 2012 in Qatar also reported fall to be the most common mechanism of injury among work-related injuries [8]. In Qatar, almost half of the severe work-related injuries affected construction workers (42%) [8]; while falls from heights were the major contributor for all work-related injuries [29]. Another study reported that the incidence of fall injuries for a period of one year was 86.7 per 100,000 workers with fatality rate of 8.44 per 100,000 workers [14].

The fatal occupational injury rates in Turkey, Egypt, Morocco, and Tunisia has been reported to be 21.2 per 100,000 employees in agriculture, 21.2 per 100,000 in industry, and

12.4 per 100,000 employees in service [30]; while in Jordan, the fatality rate was estimated to be 25.5 per 100,000 [31]. One study estimated the mortality among work-related injuries in the UAE to be 136 per 100,000 workers per year in 2009, where unintentional injuries are the second leading cause of death among the expatriate population and 21% of all non-fatal injuries were a result of work-related injuries (WRIs) [7, 28, 32]. Although the findings from our study are in concordance with the studies conducted in similar settings, variation within the countries of the Middle East cannot be ignored.

The GBD study suggests that although the burden of disease due to falls has decreased globally over the period from 1990 to 2017, however it still remains the top three contributor to the DALY rates among men and women alike [2].

4.5.4 Study Strengths and Limitations

Our study describes the most recent and to our knowledge the first ever regional analysis of trends and patterns of fall injuries in Abu Dhabi by age group, gender, type of fall, morbidities, and mortality. The strength of our analysis is the large sample size and we have utilised the data registries from seven facilities in Abu Dhabi. These findings need to be evaluated for generalizability and comparison with countries with similar circumstances. The results of our study can at least serve as a baseline for future surveillance studies to generate policy regarding fall prevention and management in the region.

Despite a large and diverse population sample in our study, there are certain limitations of our study. First, the findings and implications are derived from retrospective registry data and hence the inherent limitations of data from these registries cannot be ignored. Studies based on registry data are often prone to limitations related to the data quality and errors made while collecting the data and some of the data entries might have been excluded due to data quality. Second, for this analysis we used the data from the first four years of the registry, which might involve a learning curve and numerous limitations. We believe that the data quality will get better, and so will future analyses. Third, not all the patients with falls come to the hospital; many patients with non-fatal and non-serious falls might seek care at other outpatient healthcare settings and hence this data might fail to include cases of falls who seek care at other healthcare facilities rather than hospitals. Moreover, since the study relied on existing data, we could not explore further variables that might have been part of trauma-related morbidities, complications, and the long-term consequences impacting the DALYs.

4.5.5 Policy Implications

This paper reports the current burden of fall injuries and work-related falls in Abu Dhabi and similar settings, highlighting the gaps in current approaches to fall prevention and especially workplace fall prevention. First and foremost, there is a need to strengthen the baseline surveillance system capturing data for injuries and falls. This is imperative since the Gulf countries have their own unique accident characteristics, causal factors, and remedial interventions that are incomparable to any other settings. Context-specific policies and interventions can only be implemented if there is baseline data and a strong registry to monitor progress.

Second, efforts should be made toward risk factors identification and consequent mitigation in order to reduce the burden of falls, specifically in the context of work-related falls. Several interventions can be implemented to minimize this preventable cause including enforcing safety measures for workers and building sites. Third, our data suggest that patients are a heterogeneous mix of guests working without a common language, work culture, or labour practices. This needs to be streamlined through not only making policies that are related to skills, safety, and training but also through enforcement of these laws. Fourth, the place of fall for more than half of the patients was home; therefore, efforts should be made to reduce environmental hazards at home as much as possible and render homes hazard free. Awareness of injury preventive measures and first aid interventions can help in minimize this hazard. This can be a mandatory part of schools' curriculums and domestic workers educations. And last, we must ensure appropriate access to healthcare and rehabilitation of people suffering long-term disability as a result of the injuries. Considering the burden of falls and their associated morbidity, it is of prime importance to consider the health and wellbeing of the patients to not only ensure individual well-being but also impact the nation's productivity.

The framework created by the WHO could be adapted to achieve these goals. It focuses on starting with streamlining data collection on the patterns, environment, and workers' health policies; assessment of risks; education for employers and workers; participation in prevention campaigns; and referral to necessary services [5, 33]. This framework builds upon the relationship of problem identification; analytical injury research to facilitate the development and implementation of strategies; and continuous monitoring and evaluation of interventions [5]. The framework can be adapted in the context specific manner for not only Abu Dhabi but can act as a baseline to be expanded from the facility level in Abu Dhabi to the whole of the UAE region and the Middle Eastern region to bring about a positive impact throughout the region. This could work as a baseline framework and consequently be adjusted based on the context of Abu Dhabi and similar regions in order to make an achievable impact towards the SDGs.

4.6 CONCLUSION

To our knowledge, this paper presents the first ever study summarising data around fall patterns in Abu Dhabi. Our data provides significant insights about the epidemiology and determinants of falls with a potential to help plan and implement future policies related to fall prevention and management in the region.

4.7 REFERENCES

1. *WHO, Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018. 2018.*

2. *James SL, Castle CD, Dingels ZV, Fox JT, Hamilton EB, Liu Z, Roberts NL, Sylte DO, Henry NJ, LeGrand KE, Abdelalim A. Global injury morbidity and mortality from 1990 to 2017: results from the Global Burden of Disease Study 2017. Injury Prevention. 2020 Oct 1;26(Supp 1):i96-114.*

3. *Al-Rubaee, F.R. and A. Al-Maniri, Work related injuries in an oil field in Oman. Oman medical journal, 2011. 26(5): p. 315.*

4. *Dahdah, S. and D. Bose, Road traffic injuries: a public health crisis in the middle east and north africa. Transport Notes TRN-4, 2013.*

5. *Mehmood, A., et al., Work related injuries in Qatar: a framework for prevention and control. Journal of occupational medicine and toxicology, 2018. 13(1): p. 29.*

6. *UAE Population Statistics in 2019 (Infographics). 2019; Available from: https://www.themedialab.me/uae-population-statistics-2019/#:~:text=The%20UAE%20Population%20in%202019,provided%20by%20the%20World%20Bank.*

7. *Barss, P., et al., Occupational injury in the United Arab Emirates: epidemiology and prevention. Occupational medicine, 2009. 59(7): p. 493-498.*

8. *Al-Thani, H., et al., Workplace-related traumatic injuries: insights from a rapidly developing Middle Eastern country. Journal of environmental and public health, 2014. 2014.*

9. *Christensen-Rand, E., A.A. Hyder, and T. Baker, Road traffic deaths in the Middle East: call for action. Bmj, 2006. 333(7573): p. 860.*

10. *Wagstaff, A., Poverty and health sector inequalities. Bulletin of the world health organization, 2002. 80: p. 97-105.*

11. *Nantulya, V.M. and M.R. Reich, Equity dimensions of road traffic injuries in low-and middle-income countries. Injury control and safety promotion, 2003. 10(1-2): p. 13-20.*

12. *Organization, W.H., Eastern Mediterranean status report on road safety: call for action. 2010.*

13. *Asim, M., et al., Blunt traumatic injury in the Arab Middle Eastern populations. Journal of emergencies, trauma, and shock, 2014. 7(2): p. 88.*

14. *Tuma, M.A., et al., Epidemiology of workplace-related fall from height and cost of trauma care in Qatar. International journal of critical illness and injury science, 2013. 3(1): p. 3.*

15. *Zekri, M.K.S., Construction safety and health performance in Dubai. Unpublished thesis). Heriot Watt University, Dubai, 2013.*

16. *Nwomeh, B.C., et al., History and development of trauma registry: lessons from developed to developing countries. World journal of emergency surgery, 2006. 1(1): p. 32.*

17. *Zehtabchi, S., et al., Trauma registries: history, logistics, limitations, and contributions to emergency medicine research. Academic Emergency Medicine, 2011. 18(6): p. 637-643.*

18. *StataCorp, L., Stata multilevel mixed-effects reference manual. College Station, TX: StataCorp LP, 2013.*

19. *Allen, M.P., Understanding regression analysis. 2004: Springer Science & Business Media.*

20. *Bener, A., et al., Trends and characteristics of injuries in the State of Qatar: hospital-based study. International journal of injury control and safety promotion, 2012. 19(4): p. 368-372.*

21. *Ansari, S., et al., Causes and effects of road traffic accidents in Saudi Arabia. Public health, 2000. 114(1): p. 37-39.*

22. *El-Sadig, M., et al., Road traffic accidents in the United Arab Emirates: trends of morbidity and mortality during 1977–1998. Accident Analysis & Prevention, 2002. 34(4): p. 465-476.*

23. *Mamtani, R., et al., Motor vehicle injuries in Qatar: time trends in a rapidly developing Middle Eastern nation. Injury prevention, 2012. 18(2): p. 130-132.*

24. *El-Matbouly, M., et al., Traumatic brain injury in Qatar: age matters—insights from a 4-year observational study. The Scientific World Journal, 2013. 2013.*

25. *Atique, S., et al., Trauma caused by falling objects at construction sites. Journal of trauma and acute care surgery, 2012. 73(3): p. 704-708.*

26. *Al-Shammari, N., S. Bendak, and S. Al-Gadhi, In-depth analysis of pedestrian crashes in Riyadh. Traffic injury prevention, 2009. 10(6): p. 552-559.*

27. *Al-Omari, B.H. and E.S. Obaidat, Analysis of pedestrian accidents in Irbid City, Jordan. Open Transp. J, 2013. 7(1): p. 1-6.*

28. *Grivna, M., H.O. Eid, and F.M. Abu-Zidan, Epidemiology, morbidity and mortality from fall-related injuries in the United Arab Emirates. Scandinavian journal of trauma, resuscitation and emergency medicine, 2014. 22(1): p. 51.*

29. *Al-Thani, H., et al., Epidemiology of occupational injuries by nationality in Qatar: evidence for focused occupational safety programmes. Injury, 2015. 46(9): p. 1806-1813.*

30. *Takala, J., et al., Global estimates of the burden of injury and illness at work in 2012. Journal of occupational and environmental hygiene, 2014. 11(5): p. 326-337.*

31. *Rabi, A.Z., et al., Fatal occupational injuries in Jordan during the period 1980 through 1993. Safety Science, 1998. 28(3): p. 177-187.*

32. *Gomes, J., O. Lloyd, and N. Norman, The health of the workers in a rapidly developing country: effects of occupational exposure to noise and heat. Occupational medicine, 2002. 52(3): p. 121-128.*

33. *Organization, W.H., Global strategy on occupational health for all: the way to health at work, recommendation of the Second Meeting of the WHO Collaborating Centres in Occupational Health, 11-14 October 1994, Beijing, China. 1995, Geneva: World Health Organization.*

CHAPTER 5: CONCLUSIONS AND IMPLICATIONS

5.1. GENERAL DISCUSSION

In 2010, a trauma-interested group in Abu Dhabi, consisting of Emergency Physicians and Trauma Surgeons, attempted to work on establishing a trauma system in the Emirate of Abu Dhabi, with a belief that establishing such a system would certainly help reduce mortality and morbidity as well as revolutionize trauma care in Abu Dhabi and the UAE. Under the supervision of the Department of Health in Abu Dhabi (formerly called Health Authority – Abu Dhabi or HAAD), this team worked to plan, organize, implement, and monitor the development of a state-of-the-art trauma system, and the initiative was named Abu Dhabi Trauma System Initiative. The initiative consisted of all components of a system, including: prevention; outreach and education; pre-hospital trauma care; inter-facility transfer; hospital organization and trauma programs; rehabilitation; trauma registry; performance and patient safety (PIPS) programs; upgrading rural trauma care; and, finally, focusing on research and scholarship. A major milestone of this initiative was the establishment of an Abu Dhabi regional trauma registry at multiple facilities following the practices at the National Trauma Data Bank® (NTDB®), the largest aggregation of the United States trauma registry data ever assembled, and therefore enabling the UAE to set better strategies to care for the trauma patient.

Since the establishment of the Abu Dhabi Trauma Registry in 2014, there has been no comprehensive analysis of the data to date. This dissertation aimed to enrich the literature with robust papers concerning the Trauma Registry in the Emirate of Abu Dhabi. Through this dissertation, we reviewed the Trauma registry data between 2014 until 2017 of all the facilities involved, but we decided to only include seven facilities and exclude the others due to incomplete data.

5.2 RESEARCH AIMS

The overall purpose of this dissertation was to evaluate the efforts in developing the registry, identify opportunities for improvement, and provide the first summary of data collected to date. Specifically, following the three aims we: (1) evaluated the quality of the registry and identified areas for improvement; (2) used the registry data to examine the epidemiology of trauma and outcomes in Abu Dhabi; and (3) studied the epidemiology of falls in the registry. Results for each of these three major aims of this dissertation are as follows.

5.2.1 Aim 1:

In this first aim, the evaluation of the quality of the registry data and identification of areas for improvement were determined. For this purpose, Wang and Strong's conceptual model for measuring DQ using six domains was utilized. A random sample of 5% was selected from the qualifying 17,827 cases and the data quality was assessed on a sample of 891 cases. The study found that the data completeness was 100% complete for variables including age and gender. Among all the 14 variables, *Completeness* ranged between 99.8% for Hospital Discharge Disposition and 54% for trauma and injury severity score (TRISS). Overall, data *Accuracy* ranged between 90.6% and 99.16%. Overall *Concordance* ranged from 95% to almost 100%. For *Correctness*, the imputation process is automated and consistent with the edit rules and the built-in processes in the registry of American College of Surgeons (ACS) standards. For *Consistency*, all data elements were consistent within the data dictionary and conformed to data dictionary standards.

For *Timeliness*, about 70% of the overall data was entered within 60 days of the injury while 73% of the data was entered within 90 days. On a per-facility basis, data entered within 60 days ranged between 5% and 92% while data entered within 90 days ranged between 11% and 97%. Overall, the minimum time to close was within the same day of entry while the maximum time to close was about 4.5 years. For *Coverage*, currently the data registry is comprised of data from the seven facilities in Abu Dhabi; 100% coverage will eventually be achieved once the registry expands to other health institutes in Abu Dhabi.

Overall, Chapter 2 (representing Aim 1) focused on analysis of the data quality of a trauma registry in Abu Dhabi that summarizes the data quality across seven domains. The results are reassuring and give confidence on the importance of "investing" in the data quality and coverage in the region. The Department of Health should facilitate the expansion of the trauma registry to cover Abu Dhabi Emirate and set a model for the region.

5.2.2 Aim 2:

For the second aim, the registry data was utilized to examine the epidemiology of trauma in Abu Dhabi for the same duration (2014–2017). To accomplish this research objective, a description of the patterns of trauma injuries in the Emirate of Abu Dhabi based on the data from the Trauma Registry was obtained.

Overall, Chapter 3 of this dissertation summarized data from large facility-based registries from seven facilities from Abu Dhabi describing regional demographic patterns, trauma mechanisms, injury severity, outcomes, predictors of length of hospital stay, and mortality among trauma patients in Abu Dhabi. The final analysis was performed on a sample of 17,827 cases from the registry. The two major mechanisms of injuries (over 70%) were road traffic injuries (39%) and falls (34%). The study found that public roads and homes were the most common places of injury. Regression analysis suggested a statistically significant increase in the length of a patient's hospital stay with increasing age and increasing ISS score. There was no difference in the length of hospital stay or mortality rates by gender. Moreover, the findings from our study suggest that the majority of the trauma patients in Abu Dhabi were male and aged 21 to 50 years old.

In addition, the results demonstrated that about 30% of injuries occurred at home and the top three mechanisms of injury at home were burns, falls and assault/biting. Homes are usually considered safe places, but these findings imply that efforts need to be made to make homes safer in order to prevent burns, falls, assault/biting, and other penetrating wound injuries occurring at home. The majority of the other injuries (including cuts from broken glass, environmental [heat/cold], hit by falling/moving object, machinery, poisoning, and sexual assault) occurred at worksites. About 16% of all injuries were work-related; the mechanism of injury for 44% of the work-related injuries was a fall. Home safety education seems to be an obvious gap which need to be bridged. This can range from adding safety modules to schools' curriculums to offering mandatory awareness injury prevention and first aid courses to domestic workers in homes.

5.2.3 Aim 3:

In this third aim, the Epidemiology of Falls from Height in the Emirate of Abu Dhabi was reviewed using the same data between 2014–2017. We found that the overall mean length of stay for patients admitted with falls was 6.49 days; ranging between the lowest mean number of days of stay (3.75 days) for falls under 1 meter and highest mean number of days of stay (13.68 days) for falls over 6 meters. The place of fall for almost 55% of the patients was home while worksite was the place of injury for about 21% of the patients.

In our sample, the overall mortality among the patients admitted after a fall was approximately 1%, which is lower compared to other countries; this could be attributable to the fact that patients with severe fall injuries might have died before arriving at the hospital. Height of fall appears to be the major determinant of morality since mortality within each ISS category was higher for falls > 6 meters compared to falls < 6 meters. Among work-related falls, mortality was about 1% for falls < 6 meters while 8% for falls > 6 meters. Among non-work-related falls, mortality was about 0.5% for falls < 6 meters while 6% for falls > 6 meters. Regression analysis suggests a statistically significant increase in the length of hospital stay with increasing age and increasing ISS score. Mortality was significantly higher for falls > 6 meters compared to falls < 1 meter and 1–6 meters. Height safety seems to be another obvious gap which needs urgent intervention. This can include regular safety inspection of the construction sites in addition to offering mandatory awareness injury prevention and first aid courses to the workers at those sites.

5.3 STRENGTHS OF THE OVERALL STUDY:

This study holds several strengths and adds multiple contributions to the field of trauma care and public health. First, the study is the most recent and, most probably, the first ever regional analysis of data quality of the trauma registry in Abu Dhabi. The results from our study can serve as the baseline to enable trauma experts and policy makers to learn more about the magnitude of trauma in Abu Dhabi and can lead to a better understanding of the strengths and weaknesses of the current practices. A major strength of this project is the ability to look at the quality of this registry using a very rigorous scientific methodology. Another strength is the comprehensiveness of this registry which has over 20,000 cases with over 300 variables per case for the defined duration. The software used is an internationally recognized software which allows us to benchmark data internationally. The overall high-quality data collected in the registry boosts the confidence in the findings, which can be utilized to improve the current system and share the experience with the scientific community.

Through this dissertation, we have provided a detailed analysis of the epidemiology of trauma in Abu Dhabi highlighting age group, gender, mechanism of injury, and place of injury. Furthermore, the work sheds light on significant findings including the importance of refocusing on home safety and occupational injuries. The large study population is similar to the population in the Emirate of Abu Dhabi, but further studies are needed to evaluate the generalizability of our findings.

In addition, trauma care has been one of the highest priorities to the government with a clear intention to intervene to decrease the mortality and the morbidity. Therefore, results of our study can at least serve as a baseline for future surveillance studies to generate policy regarding fall prevention and management in the region.

5.4 LIMITATIONS OF THE STUDY:

In addition to the identified strengths, the study contained several limitations. A major limitation in the project is that the Registry is limited to seven main facilities in the Emirate of Abu Dhabi, which can be a limitation of "coverage" of the registry and the generalizability of the data. However, based on local trauma clinicians' impressions, the seven facilities see the majority of major trauma in the Emirate, either by being the first receiving facility or by receiving a referral from another hospital.

Another limitation is the type of data used for the study which followed voluntary quality assurance processes since the start. Very few facilities within the system have full-time staff to enter the data which may have affected the quality of data entered and therefore, the analysis quality. The lack of funding for this project may limit the resources used to conduct the study. The most crucial limitation is the study timeline. Data quality studies may require more time compared to the timeframe we had available, which was from 2014 to 2017, which in turn limited the size of the data pool.

In summary, the findings and implications were derived retrospectively from a data registry. Studies based on data registries are often prone to limitations related to the data quality and errors that occur during data collection. In our study, we used the data from the first four years of the registry, which might be problematic due to the learning curve and other limitations. We believe that future analysis based on the data from our data registry will be of better quality leading to more generalizable analysis and estimates as the data quality improves. Second, not all the injury patients come to the hospital for treatment; many patients with non-fatal injuries might seek care at other outpatient health care settings and hence this data might have missed those cases who seek care at other healthcare facilities rather than hospitals. Third, since our study relied on the existing data from a trauma registry, we could not explore variables like trauma-related morbidities, complications, and the long-term consequences impacting the DALYs. This limits our study's analytic generalizability.

5.5 POLICY AND PUBLIC HEALTH IMPLICATIONS:

Findings from the current study hold multiple implications. These dissertation findings will enable local trauma experts and policy makers to be able to evaluate trauma as a public health challenge and also to be able to tailor specific interventions to decrease the mortality and the morbidity of victims and eventually improve the outcomes of trauma care in the Emirate. This will hopefully influence the regional trauma care as there is a significant interest in the region but with limited data and publications to guide this interest. In order to further improve trauma care in Abu Dhabi, we also anticipate better governmental investment in the emergency care sector. Additionally, the seven facilities included in this dissertation are the major trauma facilities in the Emirates and this study provides a baseline assessment for improving the data quality and existing coverage of the trauma registry in the region.

Also, the dissertation reports the current burden of trauma in Abu Dhabi, highlighting the importance of investing in trauma prevention. There is a need to strengthen and expand the coverage of the trauma registry to ensure complete inclusion of all traumas. A systematic review assessing the epidemiology and prevention of trauma in the Middle East suggests that population-based studies on the incidence, mechanisms, prevention, and outcomes of trauma are not well-documented [6]. Context-specific policies and interventions can only be implemented if there is baseline data and a strong surveillance system to monitor progress.

Policy formulation and enforcement related to skills, safety, and training for trauma prevention is needed in order to achieve the SDG targets of reducing the burden of trauma. Home and work safety should be a primary focus over the next few years to ensure adequate preventive measures since much of the focus has already been placed on road traffic injuries. Regulations need to be in place in order to minimize injuries occurring at home and implementation of these regulations should be ensured.

Furthermore, its implications include reporting of the current burden of fall injuries and work-related falls in Abu Dhabi and similar settings, highlighting the gaps in current approaches to fall prevention and especially workplace fall prevention. This study highlights that there is a need to strengthen the baseline surveillance system capturing data for injuries and falls. This is imperative since the Gulf countries have their own unique injury characteristics, causal factors, and remedial interventions that are incomparable to any other settings. Context-specific policies and interventions can only be implemented if there is baseline data and a strong surveillance system to monitor progress. Mandating trauma-reporting to the registry is a crucial step that we hope will be an outcome of our recommendations.

Second, this, these study results imply that efforts should be made toward risk factors identification and consequent mitigation in order to reduce the burden of falls, specifically in the context of work-related falls. Third, the findings suggest that patients are a heterogeneous mix of guests working without a common language, work culture, or labor practices. This situation needs to be prioritized through not only making policies that are related to skills, safety, and training but also through enforcement of these laws. Fourth, place of fall for more than half of the patients was home; therefore, efforts should be made to reduce environmental hazards at home as much as possible and render homes hazard free including the educational activities and safety inspections. Last, the dissertation results may be useful for highlighting the need for ensuring appropriate access to healthcare and rehabilitation of people suffering long-term disability as a result of their injuries. Considering the burden of falls and their associated morbidity, it is of prime importance to consider the health and wellbeing of the patients to not only ensure individual well-being but also impact the nation’s productivity.

5.6 FUTURE RECOMMENDATIONS:

Since it is the first known attempt in analyzing the trauma registry in Abu Dhabi, the implications of the information obtained from the study support the call for additional research. Further research is needed to expand which measures should be taken for the identification of risk factors and consequent mitigation in order to reduce the burden of trauma. Also, determining how the framework created by the WHO for the assessment of trauma and its risks could be adapted to achieve these goals should be examined since it focuses on starting with streamlining data collection on the patterns, environment, and workers’ health policies; assessment of risks; education for employers and workers; participation in prevention campaigns; and referral to necessary services [7, 8]. Therefore, future research should adopt this framework to determine the relationship of problem identification and analytical injury research to facilitate the development and implementation of strategies and continuous monitoring and evaluation of interventions [7]. Also, the framework can be adapted in a context specific manner, not only for Abu Dhabi, but it can act as a baseline to be expanded from the facility level in Abu Dhabi to the whole of the UAE and the Middle Eastern region to bring about a positive impact throughout the region. There is a need to utilize this framework in the context of other countries as well.

Most importantly, the future research should assess a registry with wider coverage, so there is no bias in the findings and results that can be obtained. Furthermore, the quality of data used for the research should be higher with a longer timeframe compared to the timeframe we had available, which was from 2014 to 2017, which in turn limited the size of the data pool used for analysis. Home and work safety can be a rich subject for future research and can improve the current understanding.

5.7 CONCLUSIONS:

This dissertation brings to the forefront an in-depth analysis of the trauma registry in Abu Dhabi with a special focus combining the quality of data and the epidemiology of injuries. The findings of this research will be a cornerstone to facilitate the planning and the implementation of policies related to trauma prevention in the Emirate of Abu Dhabi. Most importantly, this is the first known attempt at summarizing data around fall patterns in Abu Dhabi. The data utilized for the analysis and summarization can provide significant insights about the epidemiology and determinants of falls with a potential to help plan and implement future policies related to fall prevention and management in the region. These important dissertation results will hopefully support the local and national efforts toward a national trauma registry and a more mature trauma system.

5.8 REFERENCES

1. *Fares, S., Irfan, F. B., Corder, R. F., Al Marzouqi, M. A., Al Zaabi, A. H., Idrees, M. M., & Abbo, M. (2014). Emergency medicine in the United Arab Emirates. International journal of emergency medicine, 7(1), 4.*
2. *Sobel, J., Khan, A.S., Swerdlow, D.L., 2002. "Threat of a biological terrorist on the US food supply: the CDC perspective." Lancet 359, 874–880*
3. *HAAD Annual Report 2010. http://www.haad.ae/haad/2010_English%20HAAD%20Annual%20Report/ Accessed on March 6, 2016.*
4. *Cameron PA, Gabbe B, Cooper DJ. A statewide system of trauma care in Victoria: effect on patient survival. Med J Aust 2008; 189:546–50*
5. *Wang RY, Storey VC, Firth CP. A framework for analysis of data quality research. IEEE Transactions on Knowledge and Data Engineering. 1995;7(4): 623-640*
6. *Asim, M., et al., Blunt traumatic injury in the Arab Middle Eastern populations. Journal of emergencies, trauma, and shock, 2014. 7(2): p. 88.*
7. *Mehmood, A., et al., Work related injuries in Qatar: a framework for prevention and control. Journal of occupational medicine and toxicology, 2018. 13(1): p. 29.*
8. *Organization, W.H., Global strategy on occupational health for all: the way to health at work, recommendation of the Second Meeting of the WHO Collaborating Centres in Occupational Health, 11-14 October 1994, Beijing, China. 1995, Geneva: World Health Organization.*

APPENDICES

Appendix 1:

Level I
- Regional resource hospital that is central to trauma care system
- Provides total care for every aspect of injury, from prevention through rehabilitation
- Maintains resources and personnel for patient care, education, and research (usually in university-based teaching hospital)
- Provides leadership in education, research, and system planning to all hospitals caring for injured patients in the region

Level II
- Provides comprehensive trauma care, regardless of the severity of injury
- Might be most prevalent facility in a community and manage majority of trauma patients or supplement the activity of a Level I TC
- Can be an academic institution or a public or private community facility located in an urban, suburban, or rural area
- Where no Level I TC exists, is responsible for education and system leadership

Level III
- Provides prompt assessment, resuscitation, emergency surgery, and stabilization and arrange transfer to a higher-level facility when necessary
- Maintains continuous general surgery coverage
- Has transfer agreements and standardized treatment protocols to plan for care of injured patients
- Might not be required in urban or suburban area with adequate Level I or II TCs

Level IV
- Rural facility that supplements care within the larger trauma system
- Provides initial evaluation and assessment of injured patients
- Must have 24-hour emergency coverage by a physician
- Has transfer agreements and a good working relationship with the nearest Level I, II, or III TC

SOURCE: Adapted from the American College of Surgeons. Resources for the optimal care of the injured patient. Chicago, IL: American College of Surgeons: 2006.

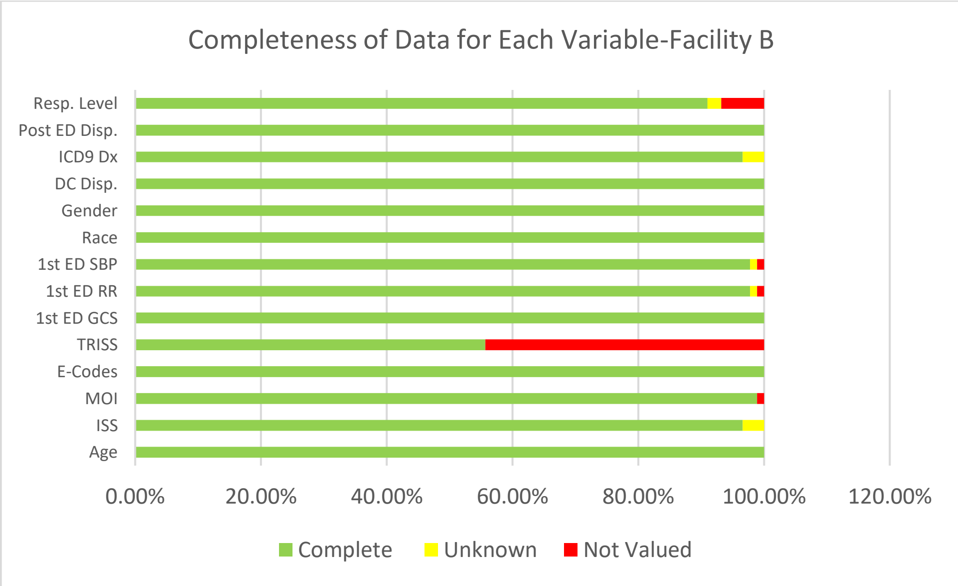
Appendix 1 Levels of Trauma Centers as per the American College of Surgeons

Appendix 2:

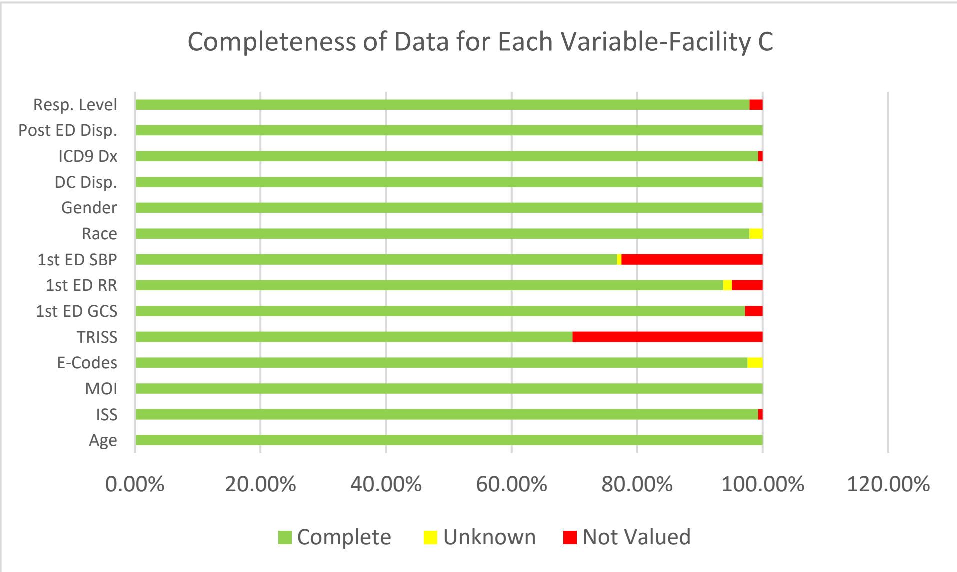
Phase of care	Quality indicator
Overall system	Number of major trauma patients Adjusted death rates Time and day of injury Severity of head injuries Overall injury severity Definitive trauma service level Transfers across the system Discharge status Observed versus unexpected deaths
Prehospital	Prehospital time >1 hour (from receipt of ambulance call until hospital admission) Prehospital scene time >20 minutes Systolic blood pressure <100mmHg on arrival and scene time >10 minutes Glasgow Coma Scale score <9 at scene and O_2 saturation <90% after 10 minutes Glasgow Coma Scale score <9 at scene and systolic blood pressure <100mmHg after 10 minutes Glasgow Coma Scale score <9 at scene and no intubation of patient
Hospital	Failure to activate a trauma team at MTS[‡] No intubation of patients with a Glasgow Coma Scale score <9 Length of time from arrival at the emergency department until a head computed tomography scan >2 hours Penetrating torso trauma with a time to operating theater >1 hour

Appendix 2 Quality Indicators as per the American College of Surgeons – Committee on Trauma

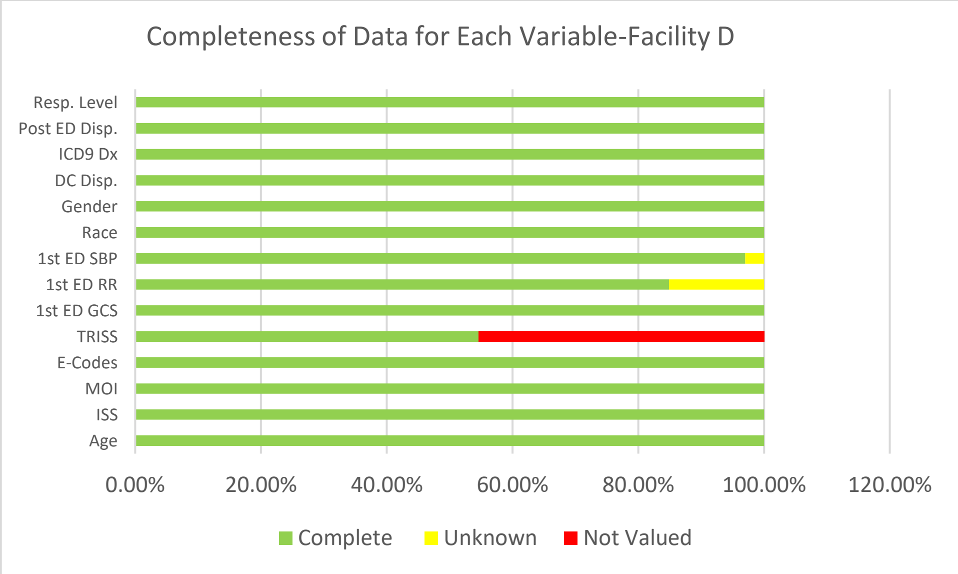
Appendix 3:

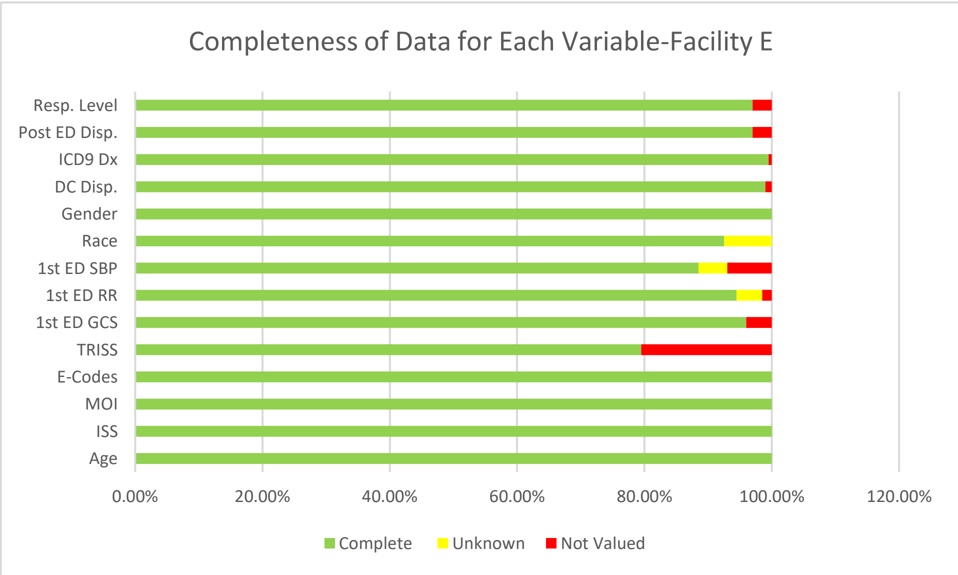


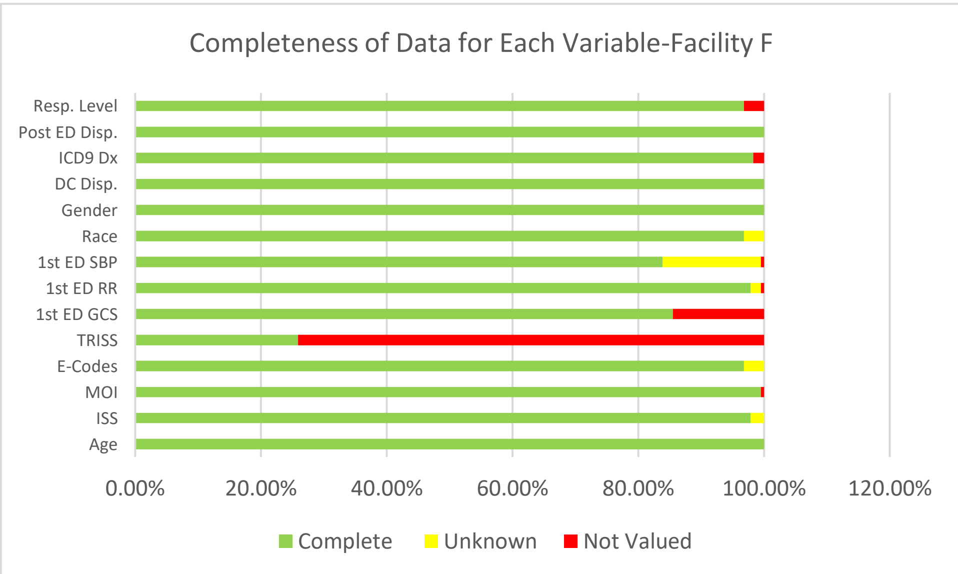
Completeness of Data for Each Variable-Facility B
Resp. Level
Post ED Disp.
ICD9 Dx
DC Disp.
Gender
Race
1st ED SBP
1st ED RR
1st ED GCS
TRISS
E-Codes
MOI
ISS
Age
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
Complete
Unknown
Not Valued

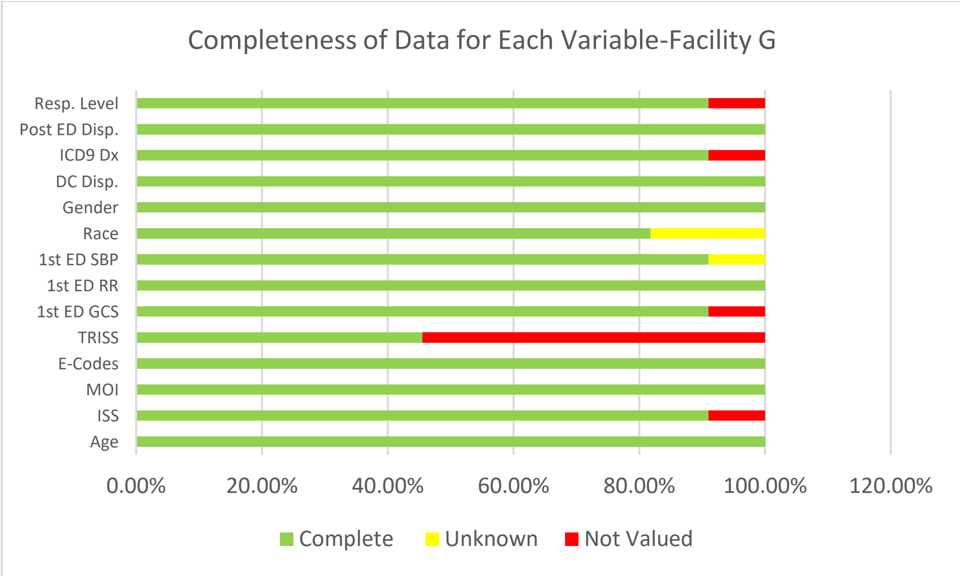


Completeness of Data for Each Variable-Facility C
Resp. Level
Post ED Disp.
ICD9 Dx
DC Disp.
Gender
Race
1st ED SBP
1st ED RR
1st ED GCS
TRISS
E-Codes
MOI
ISS
Age
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
Complete
Unknown
Not Valued


Completeness of Data for Each Variable-Facility D
Resp. Level
Post ED Disp.
ICD9 Dx
DC Disp.
Gender
Race
1st ED SBP
1st ED RR
1st ED GCS
TRISS
E-Codes
MOI
ISS
Age
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
Complete
Unknown
Not Valued


Completeness of Data for Each Variable-Facility E
Resp. Level
Post ED Disp.
ICD9 Dx
DC Disp.
Gender
Race
1st ED SBP
1st ED RR
1st ED GCS
TRISS
E-Codes
MOI
ISS
Age
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
Complete
Unknown
Not Valued


Completeness of Data for Each Variable-Facility F
Resp. Level
Post ED Disp.
ICD9 Dx
DC Disp.
Gender
Race
1st ED SBP
1st ED RR
1st ED GCS
TRISS
E-Codes
MOI
ISS
Age
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
Complete
Unknown
Not Valued



Appendix 3 Facility-Specific Completeness of Data for Each Variable